Bill Ferry

MARK CENTURY*

NUMERICAL CONTROL

GEK-25260

1050T MICROPROCESSOR CNC

GENERAL ELECTRIC

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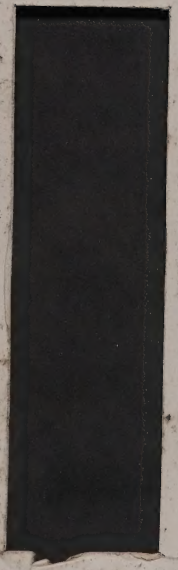

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GEK-25260

1050T MICROPROCESSOR CNC

Industrial Control Department General Electric Company
Waynesboro, Virginia 22980

GENERAL ELECTRIC

NOVEMBER, 1978

WARNING, CAUTION, AND NOTES AS USED IN THIS PUBLICATION

WARNING

Warning notices are used in this publication to emphasize that hazardous voltages, currents, and temperatures that could cause personal injury exist in this equipment.

CAUTION

Caution notices are used where equipment might be damaged if care is not taken.

In situations where inattention could cause either personal injury or damage to equipment, a Warning notice is used.

NOTE

Notes merely call attention to information that is especially significant in understanding and operating the equipment.

INDUSTRIAL CONTROL DEPARTMENT, GENERAL ELECTRIC COMPANY, WAYNESBORO, VIRGINIA

PREFACE

This instruction book is organized in such a manner as to be of optimum use to the reader.

Four publications in the book are printed on colored paper: Operating the Control, buff; Programming, blue; and Troubleshooting, and Diagnostic Software, green.

Where appropriate, individual publications have their own index.

When necessary, detailed information concerning installation, adjustments, and troubleshooting for components such as tape readers, servos, power supplies, etc. is given in the individual publications for these components.

If your Control has additional custom features, a detailed description of these features is in the chapter entitled "Options and Custom Features".

In the text, reference is frequently made to the system elementary diagrams. These diagrams are provided with your Control.

Several sheets have been provided in the back of the book for notes that the user may wish to make.

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The information contained herein does not purport to cover all details or variations in equipment nor to provide for every possible contingency to be met in connection with installation, operation, or maintenance. Should further information be desired or should particular problems arise which are not covered sufficiently for the purchaser's purposes, the matter should be referred to the General Electric Company.

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CHAPTER I

GENERAL DESCRIPTION OF THE 1050 CONTROL
INSTALLATION AND INITIAL ADJUSTMENTS
MACHINE SETUP DATA

GENERAL DESCRIPTION OF THE MARK CENTURY 1050T CONTROL

The Mark Century 1050T Control (Figures 1 - 5), provides a flexible numerical control system through the combination of a softwired computer processor and hardwired command and control devices. The Control accepts digital part program data from either punched tape, memory storage, or a Manual Data Input (MDI) operator's control panel and monitors the machine status through position and velocity control feedback devices and limit switches. From these inputs, the necessary control signals are developed and applied to the machine tool to provide continuous control of the position and motion of the machine tool slides and to control the sequencing of auxiliary machine functions such as tool change and spindle control.

Part program data is processed by the computer in a manner determined by the system executive software which includes the software modules for the options chosen for the particular installation. The executive software is loaded through the tape reader. An MSD (Machine Setup Data) tape containing codes to identify machine parameters may be spliced on the end of the executive tape. The Machine Setup Data tape is described in GEK-45671 of this chapter.

Many changing customer requirements can be met by changing or updating the executive software. Only the high speed motion commands are generated in firmware and hardware with all other data manipulation handled in software.

Should a hardware failure occur, Test and Diagnostic Programs identify the failed hardwired circuit, thus minimizing down time.

CONTROL FEATURES

The 1050T is specifically designed for 2-axis turning machines. Its major design characteristics are:

- Softwired flexibility
- Modular design
- Functional board layout
- Designed for maximum reliability and easy maintenance

BASIC CONTROL FEATURES

- Sealed vertical enclosure suitable to 120°F (49°C); humidity range 5-95%.
  Storage temperature limits -40°F (-40°C) to +149°F (65°C)
- Format: Inch - n4, g2, x+34, z+34, i34, k34, f32, s4, t4, m2
  Metric - n4, g2, x+43, z+43, i43, k43, f41, s4, t4, m2
- 6/7 Digit departure commands - selectable by Machine Setup Data
- 2-Axis contouring
- Linear and circular interpolation
- Inch or Metric data selectable by g function (ability to select start-up mode by Machine Setup Data)
- Initial zeroing by:

  Reference zero (direction and absolute position preset value selectable by Machine Setup Data)
  Set zero
  Grid zero
- Manual feedrate override 0-120% continuous
- Incremental feed, .0001, 001, 01, .1, 1.0, 10.0 inches
  .001, .01, .1, 1.0, 10.0, 100.0 mm
- Omit leading or trailing zeros (Machine Setup Data)
- Provision to accept external inputs for:

Jog pushbuttons	Control on
Feedhold	Transfer permit/Cycle start initiate permit
Emergency stop	Motion inhibit
Jog selector switch	Overtemperature warning
Remote/console selector	Limit switches (2 per axis)
Cycle Start	Reference zero (1 per axis - open at zero position)
MFO	
Automatic cycle restart	Manual/Auto mode select

- 50/60 Hertz power input at 115 VAC (+10%, -15%) single phase
- Selectable error limits
- s Word capability of s2, 3, 4 digits less BCD drivers
- 3-digit D/A spindle with percent motor speed programming in basic
- t4 word capability less BCD drivers
- m2 word capability less BCD drivers
- MAN/AUTO/SINGLE/MDI/SEQ. NO. SEARCH/ REF. STOP mode selection
- x and z axis movement outputs (for lube control)
- 150-CPS photoelectric tape reader
- 75-foot tape capacity tumble box and fanfold tape adaptors
- Tape parity check and sprocket hole checks
- Built-in test and diagnostic circuits
- Off-line board-level diagnostics
- Display of memory contents
- Tool offsets 32 pair x and z up to ±99.9999 inches (±999.999 mm). Ability to truncate value of offsets to 3 digits by Machine Setup Data
- 32 character alphanumeric display for OFFSETS/ BUFFER/ACTIVE/POSITION/G CODES/MESSAGE RECALL/PROGRAM INDEX (used with part program storage)
- IPM and IPR modal programming (g94, g95)
- Threadcutting Taper/Variable Lead (10" Lead Max.)
- Gain break (one)
- Dry run
- Multiple buffer storage
- RS-358/RS-244 automatic selection
- Optional Stop
- Absolute/Incremental programming, and position preset; g90, g91, g92
- In position zone programming (g21, g22, g23) to eliminate cornering errors
- Reversal error compensation up to .0127 in. or .254mm
- Block delete
- Vectorial traverse by selected f word - max. 800 inches/min., 16,000 mm/min (Machine Setup Data for command and exact traverse value)
- High and low jog rates independently selectable by Machine Setup Data
- Feedrate - max. 799.99 inch/min, 9999.9 mm/min for 0.1 inch or 2mm gearing at 100% MFO setting
- Dwell - g04 - x register 999.9999 seconds max. (follows x format) (Format 2.4 revolutions in IPR mode)
- Front and back access through hinged gasketed doors
- Display of servo lag (value and sign)
- Display of absolute machine position
- Provision to operate from either resolvers or inductosyns (Basic control supplied less feedback devices)
- Error messages displayed on 32-character alphanumeric display
- Battery back-up with charger for semiconductor memory (36 hours)
- Terminal boards for customer connections
- Display of actual spindle speed (RPM)

Optional Features

- Multiple part (Up to 10) program storage to 680 feet of tape in increments of 68 ft.

  Identify 10 part programs with 12 alphanumeric characters.

  Ability to load from tape reader or remote data source

- Program Edit - ability to add, delete, modify blocks
- Tape punch interface (RS232C) for externally mounted tape punch
- Parametric subroutines
- Tool offsets combined with command (CWC)
- Separate sequence number readout - n4
- Automatic forward and reverse tape search to preset sequence number (direction selected by operator)
- CSS/RPM programming for spindle
- 150 CPS GE tape reader with reels
- 300 CPS GE tape reader with and without reels
- Low cost reeler with 5-1/4" reels
- Servo drives including hydraulic valve amplifiers or Hi-AK* (PWM) servo drives
- Extension to enclosure to mount PWM servo drives
- Feedback devices including resolver and Inductosyn**
- Multiple-tapped transformer 50/60 Hz, 208/230/240/380/415/460/480/500/575/volts
- 256 character alphanumeric display
- Spindle speed override (SSO) range 50-100% or 50-120% speed
- RS-408 interface
- Programmable interface
- BCD outputs interface for m, s, t
- Battery back-up and charger to increase offtime without power to 18, 36, 54 and 72 hours
- Low voltage (48 volt) input for battery-charger
- Customer plug connections similar to 550TX interface
- Multiple MFO and SSO, t selected, quantity 8
- Multiple MFO, t selected, quantity 16
- Multiple SSO, quantity 16
- Tool inspection and retrace
- Position offsets
- Diameter programming
- Decimal point programming
- Leadscrew compensation

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GENERAL CONSTRUCTION

The Control is a solid-state, integrated-circuit controller/processor system using LSI circuits for data processing and control. The static logic circuits are arranged on modular, plug-in printed-circuit boards, clearly identified by type. The circuit boards are mounted with functional grouping. In addition, each rack slot is marked by a board identification number. The backplane consists of printed conductors arranged in a bussing structure so that each slot is universal and can accept any board type. This provides system flexibility and ease of hardware restructuring.

The executive software and Machine Setup Data (such as dimension format, traverse rate, etc.) is stored in semiconductor memory with battery backup protection during power losses or shutdown for servicing.

Operator controls are located on a front panel on the enclosure door. An auxiliary operator's panel and the tape reader are located behind a transparent paneled door on the front of the Control enclosure below the main operator's panel. Opening the door provides ready access for loading the tape reader.

External connections to the Control are made through terminal boards. These are located on a panel which is readily accessible from the rear door. An option is available which provides plugs of the same type as used in earlier Mark Century controls.

Removable plates are provided at the top, bottom, and back of the case for conduit or cable entrance for all connections. Thus, cables may be routed to a machine on the right, left, or behind the Control. The Control cabinet is totally enclosed. The Control will operate in an environment of 50°F to 120°F (10°C to 50°C) and with relative humidity of 0 to 95%.

POWER INPUT

Power input requirement for the basic Control is approximately 800 watts. The basic input voltage is 115V, 50/60 Hz single-phase. An input transformer with taps for 208, 230, 240, 380, 415, 460, 480, 500 and 575V, 50/60 Hz is available as an option. Fuses are provided in the Control. If a disconnect is required, it must be external to the Control.

DESCRIPTION OF OPERATIONS INTERNAL TO THE CONTROL

A brief description of the Control functions is given below:

DATA INPUT FORMAT

The Control is designed to operate from punched tape, manual keyboard input data, or from a stored program. Tape input is in accordance with EIA Standard RS-227.

Character coding conforms to EIA Standard RS-244 or RS-358 (ASCII). The Control automatically adjusts to read tapes with either coding by sensing the first end-of-block (EOB) character at the beginning of the tape. This feature eliminates the need for the operator to segregate tapes or to make special reader setups.

The tape format detail is given in the first column of the following tabulation. The first digit indicates the number of digits to the left of the decimal point and the second digit, when present, indicates the number of digits to the right of the decimal point. x, z, i, k, and s format may be changed by Machine Setup Data. (Refer to section 2 of this chapter.) The r format will always be the same as the x format.

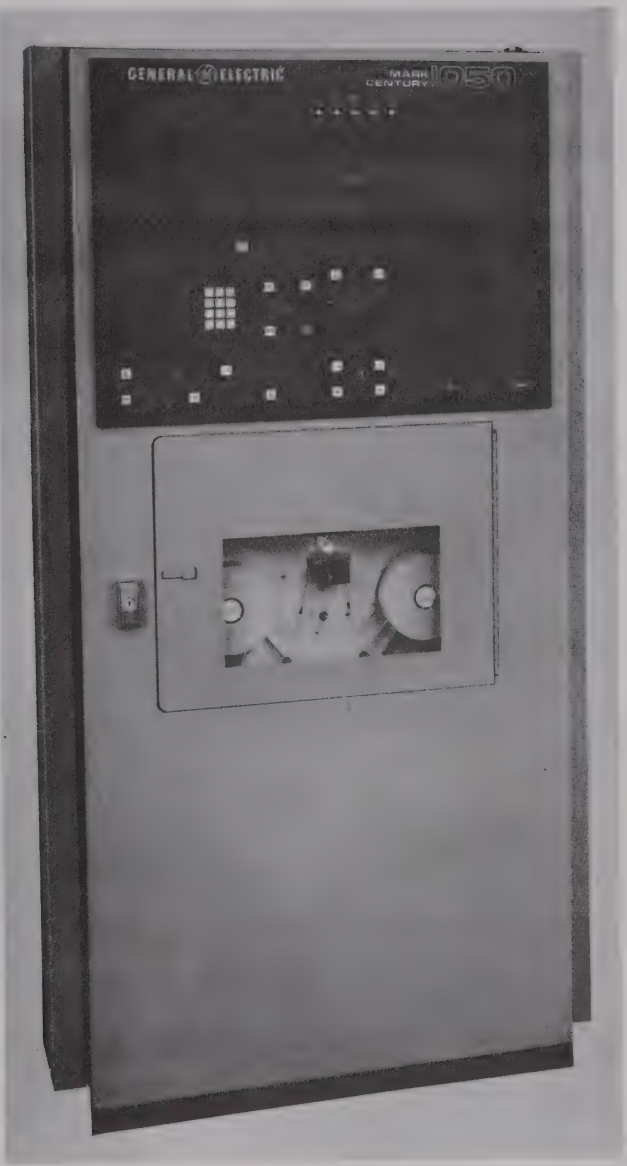
n4	Sequence number
g2	Preparatory command
x+34 (Inch), +43 (Metric)	Position command, x axis
+34 (Inch), +43 (Metric)	Position command, z axis
i34 (Inch), 43 (Metric)	Arc-Center distance, x axis
k34 (Inch), 43 (Metric)	Arc-Center distance, z axis
r+34 (Inch), +43 (Metric)	Spindle center distance for constant surface speed.
f32 (Inch), 41 (Metric)	Feed command: 0.01 to 799.99 ipm (Inch); 0.1 to 9999.9 mm/min (Metric)
f04 (Inch), 13 (Metric)	Feed command .0001 to .9999 ipr (Inch); .001 to 9.999 mmpr (Metric)
s4	Spindle command
t4	Tool command
m2	Miscellaneous command

SERVO SYSTEMS

The basic Control is designed for position-loop output of ±7.5 volts at up to 2 ma. Also available are hydraulic valve amplifiers mounted within the Control or pulse-width modulation (PWM) servos for separate mounting.

OVERTEMPERATURE PROTECTION

The Control system is protected by an Overtemperature thermostat. If the internal Control temperature reaches a set value, a warning light is turned on. If the fault is not corrected and the Control temperature continues to rise, the motions are stopped, and the Stop indicating light on the front panel turns on, the operator cannot operate the Control until the trouble is cleared and the temperature is reduced to an acceptable level.



To remove the sides, remove the two screws along the bottom edge. Then raise the panel vertically without hinging the bottom out more than approximately 3 inches.

Figure 1.
FRONT VIEW OF THE CONTROL

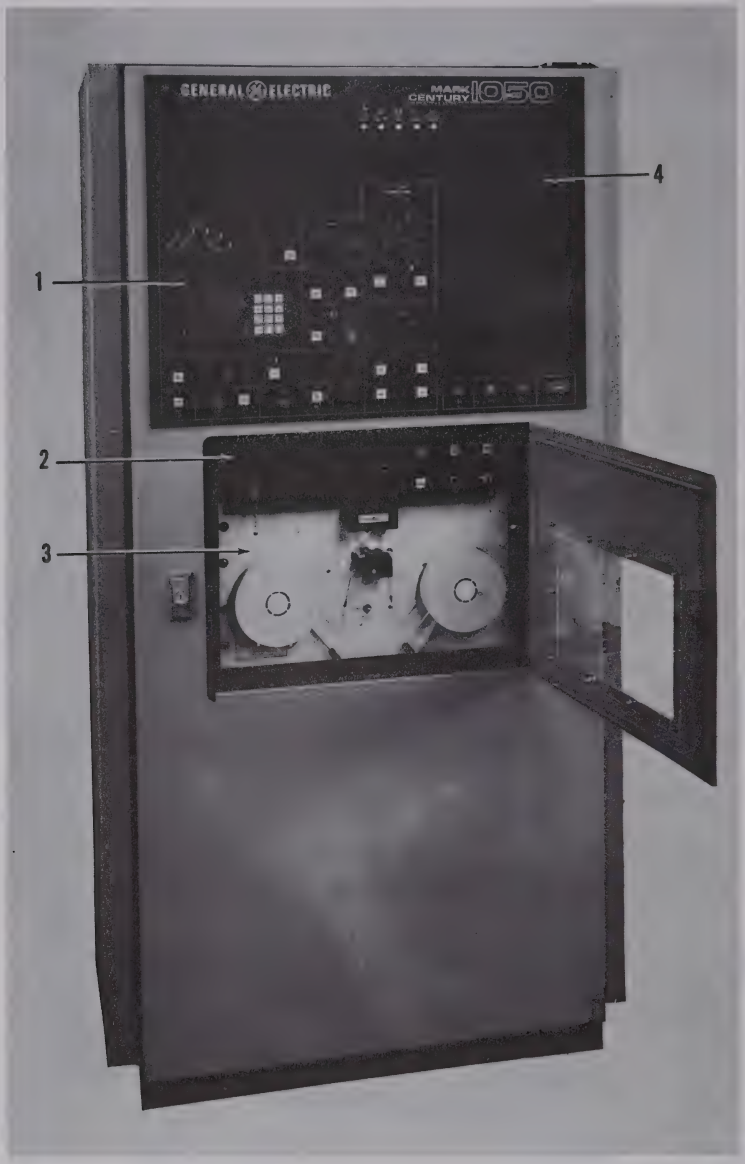


Figure 2.
FRONT VIEW OF ENCLOSURE WITH TAPE READER DOOR OPEN

1. Main Operator's Control Panel
2. Auxiliary Operator's Control Panel
3. Tape Reader
4. Customer Device Panel and/or Multiple MFO/SSO Panel

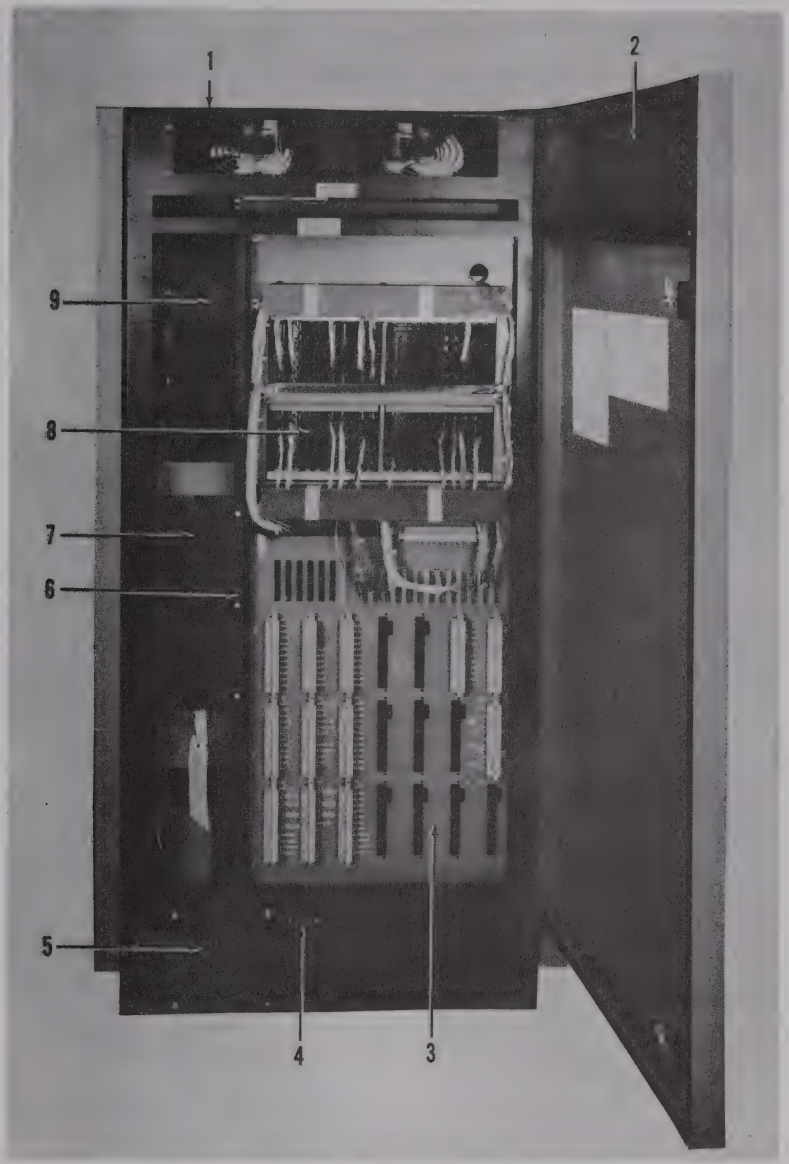


Figure 3.
REAR VIEW OF CONTROL WITH DOOR OPEN

1. Customer Cable Entry
2. Air Filter
3. Customer's Terminal Boards
4. Plug for Terminet, Teletype or Tape Punch
5. Customer Cable Entry
6. Ground Stud
7. Incoming Power
8. Main Logic Rack
9. Space for Auxiliary Logic Rack

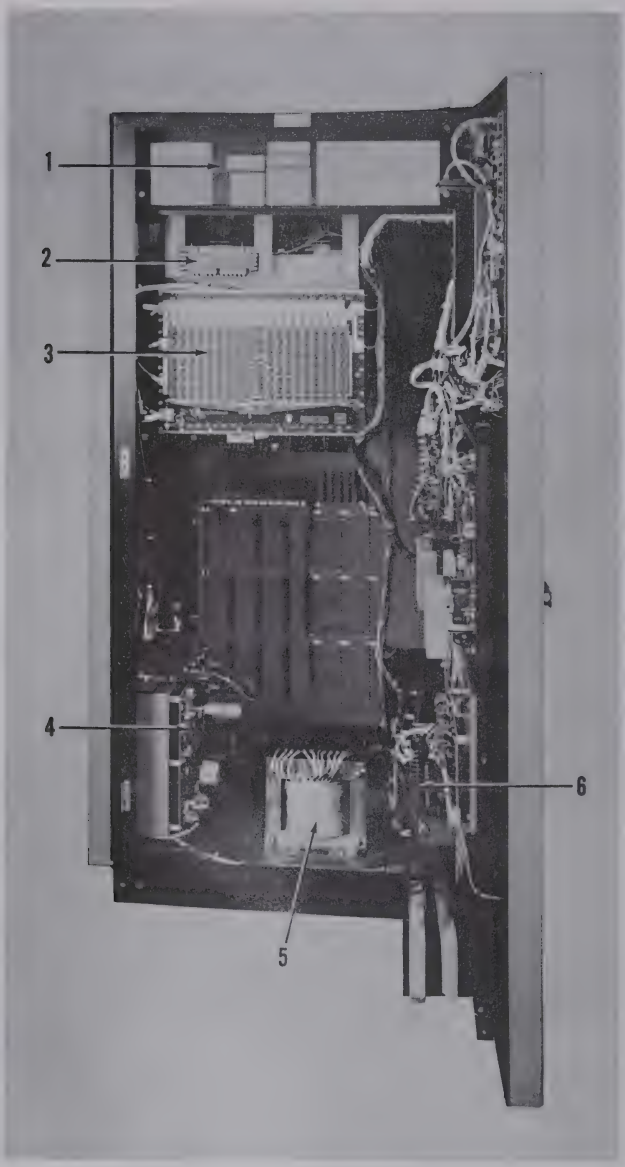


Figure 4.
FRONT VIEW OF THE CONTROL WITH DOOR OPEN

1. Batteries Located Behind the Panel
2. Axis Gain Adjustment Panel
3. P. C. Backplane
4. Logic Power Supply (+5. + -12V)
5. Input Power Transformer
6. Memory Power Supply and Battery Charger

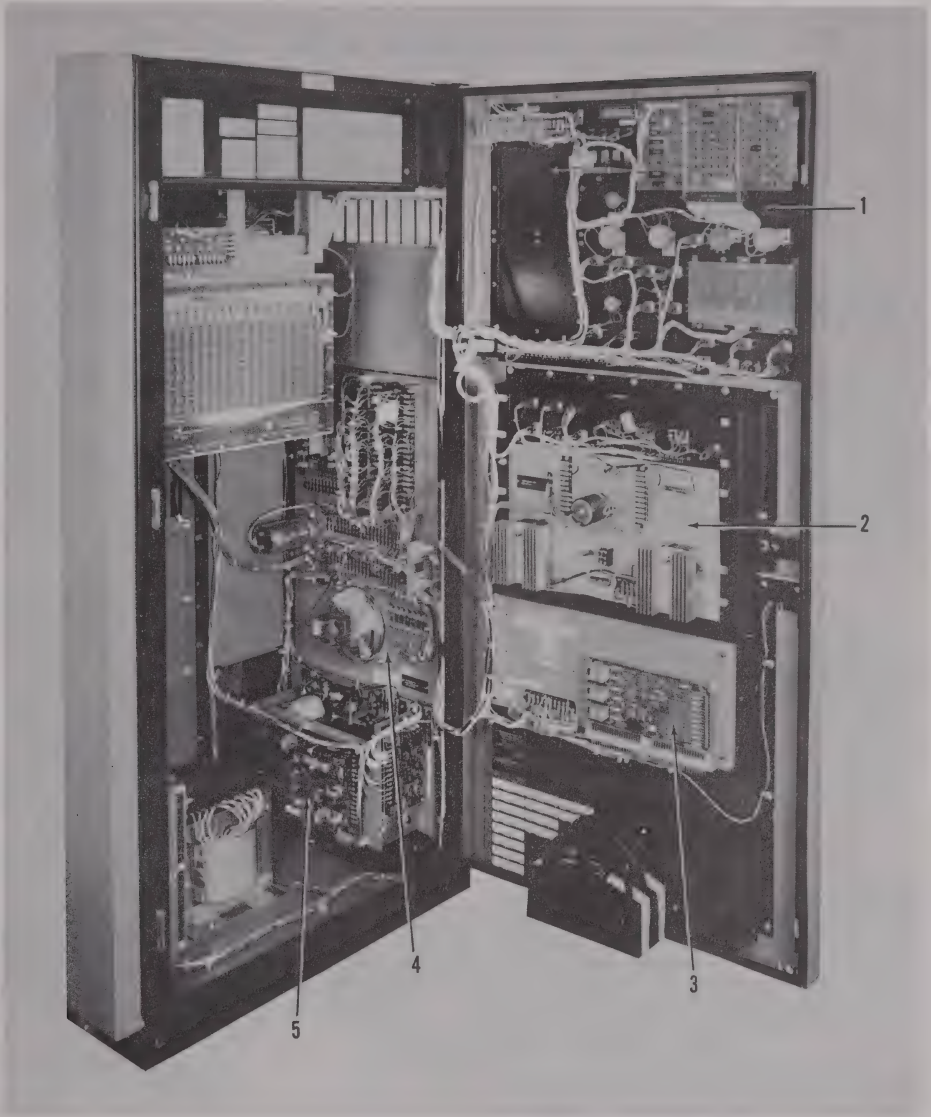


Figure 5.
FRONT VIEW OF THE CONTROL WITH DOOR OPEN
SHOWING COMPONENTS MOUNTED ON THE BACK OF THE FRONT DOOR

1. Back of Operator's Panel
2. Tape Reader
3. Tape Reader Amplifier
4. Mag Panel
5. 12 Volt Power Supply

INSTALLATION AND INITIAL ADJUSTMENTS

Installing the Control is simple and straightforward. The installation section of the elementary diagrams will aid you in locating and defining those interconnections to be made in order to interface the Control and machine. Notice that all cable entries are made through gasketed access plates at the bottom rear, bottom sides, or at the top of the enclosure.

This section presents information on how to position the Control, how to gain entrance into the Control, plus information on interconnections, incoming power, ground circuits, and noise suppression. See Figures 1 through 5 in "General Description" and Figure 1 (pages 2 and 3) of this publication.

A procedure is given for checking the Control prior to application of power and making initial adjustments after power is applied.

LOCATING THE CONTROL

The location of the Control depends on a number of factors including size of machine tool, cable routing and, of course, customer preference. Nevertheless, the following points should be given careful consideration when determining Machine Control location.

1. The Control location should permit ready access to the enclosure for maintenance. There should be sufficient clearance to permit both doors to be opened. Also, it should be possible for the maintenance men to remove the side enclosure panels for access to the Control.

2. The operator should be able to actuate the devices on his control panel while having a clear view of the machine tool.

3. When possible, the Control should be located at an angle with respect to the machine tool to prevent or at least keep to a minimum, flying chips and oil from hitting the tape reader in the event that the tape reader access door is inadvertently left open.

4. The Control should be located where it is not subject to vibration.

ENTRY INTO THE CONTROL

WARNING

HAZARDOUS VOLTAGES! SERVICING OF THIS CONTROL SHOULD BE REFERRED TO AN AUTHORIZED SERVICE TECHNICIAN.

Access is gained to the front or rear of the Control by opening the front door or rear door which are hinged. Access to both the front and back of the Control is required for Control installation. The side panels hang from the top of the enclosure and they are secured by two screws at the bottom. To lift them off after removing the screws, hinge out the bottom only enough to clear the gasket.

CAUTION

DO NOT SWING THE PANEL BOTTOMS OUT MORE THAN 6 INCHES OR THEY WILL BIND THE HANGING HOOKS AND MAY SPRING THEM OUT OF SHAPE. ALSO, SWINGING OUT THE BOTTOMS MORE THAN 6 INCHES MAY BIND THE TOP, CAUSING THE PANELS TO BE MORE DIFFICULT TO LIFT OFF THE FRAME.

CABLE ENTRY

Cable entrance to the Control is through gasketed plates at the bottom rear, bottom sides, and at the top of the enclosure. The cable entry holes at the bottom rear and top will accept either 4" x 4" or 6" x 6" standard wireway or the plates may be punched to accept the cable fittings. The cable entrances at the bottom sides are 1 3/4" x 10 1/2" cutouts with cover plates.

All cable entries are shown on the enclosure outline in Figure 1, pages 2 and 3.

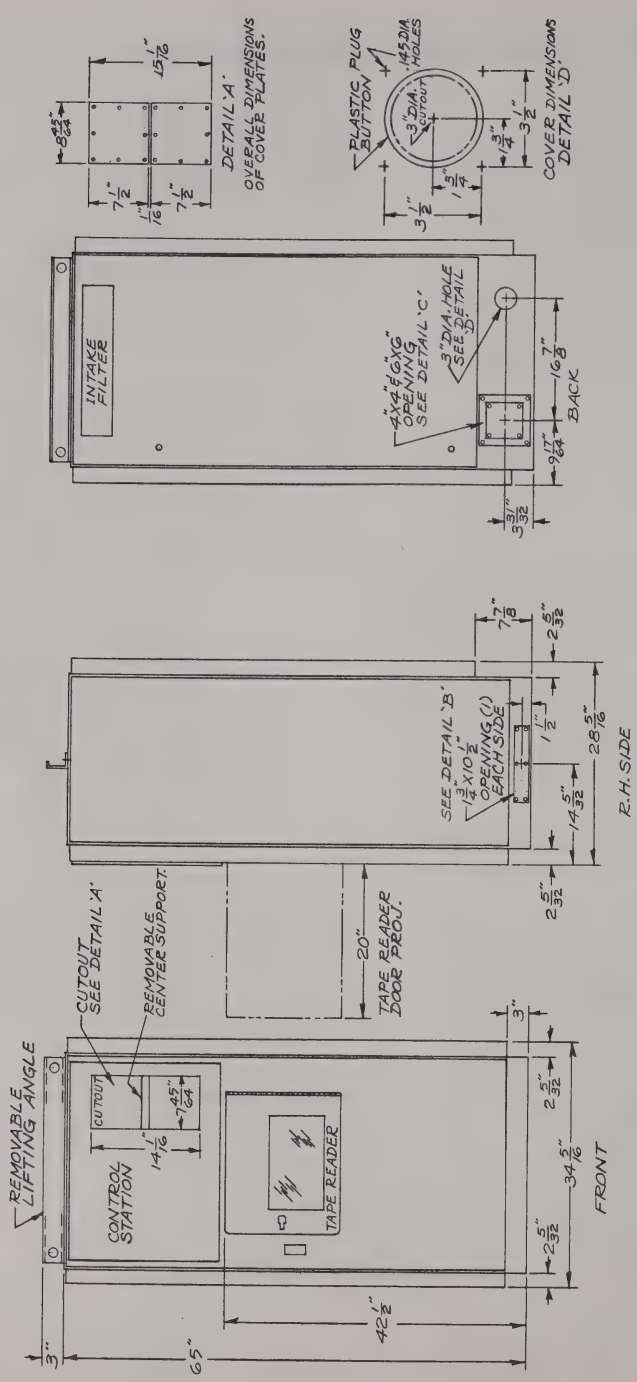


Figure 1.
OUTLINE DRAWING OF THE 1050T CONTROL
(Continued On Page 3)

Ref. 44B389555, Sheet 1
For Reference Only

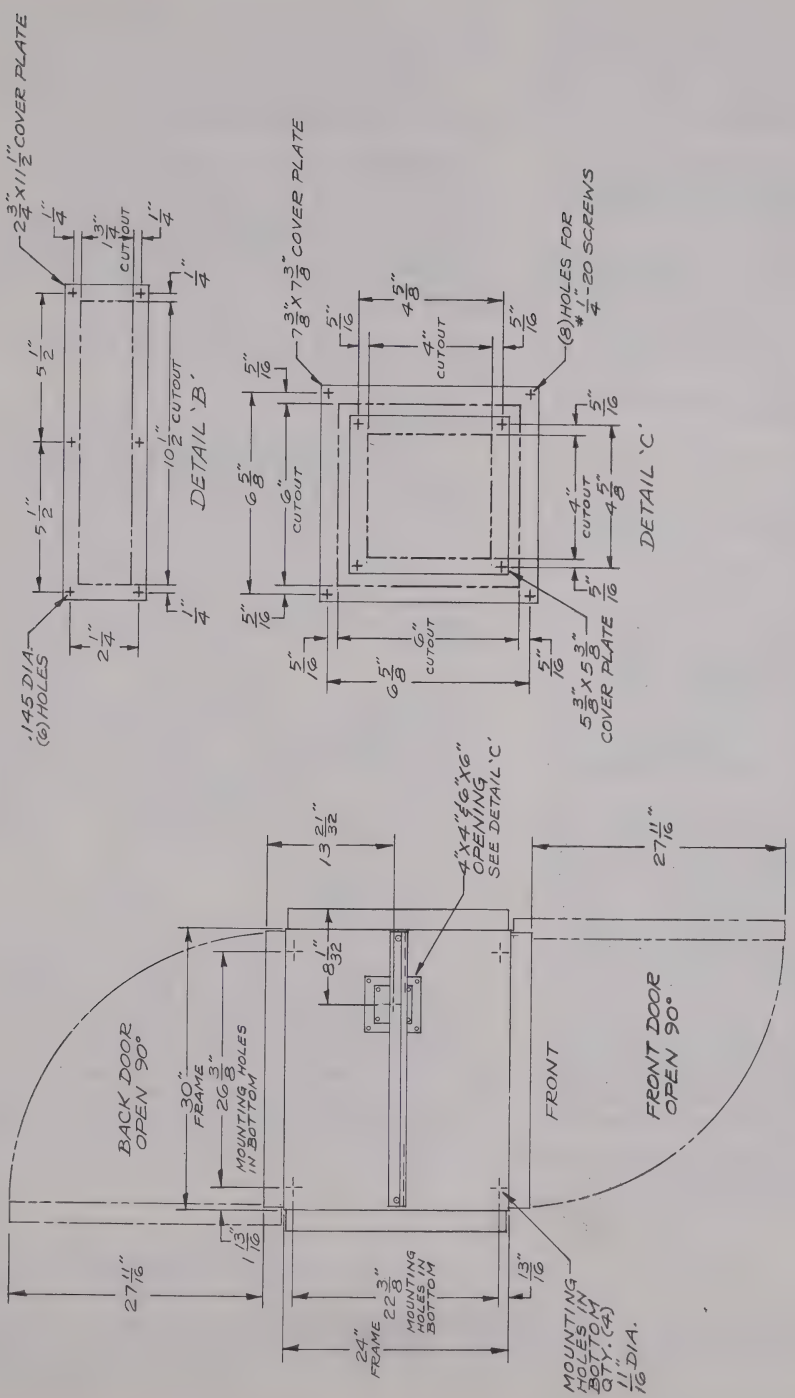


Figure 1.
OUTLINE DRAWING OF THE 1050T CONTROL
(Continued From Page 2)

VISUAL CHECKING AND UNPACKING

After the Control has been moved to its operating location and prior to starting installation, it should be given a visual inspection for any signs of damage that may have occurred in transit.

During this inspection for damage, particular attention should be given to the following:

1. Check to see that all plugs and connectors are firmly mated.

2. Be certain that all printed-circuit boards are firmly seated in their connectors.

3. Visually scan each subassembly for broken wires or components and loose terminal board screws.

4. Make the following checks to the tape reader:

ITEM	CHECK
Reader tape transport	All components are tightly secured to the front panel, there is no evidence of damage, and general alignment is obviously correct.
Lamp	The bulb is secured in the socket, and there is no visible damage.
Motors	Each motor is securely mounted, the shafts rotate with power removed, and the motor cases are intact.
Tape Tension Arms (Reeler Only)	Arms move smoothly against the spring tension when they are displaced; there is no visible evidence of damage, the arms do not scrape the panel, there is full excursion by the arms to the outer limits without binding, rollers are intact and are free to rotate.

5. If it appears that there is damage to the Machine Control due to shipping, report this to the carrier immediately. Also notify the General Electric Company.

CONNECTING INCOMING AC POWER

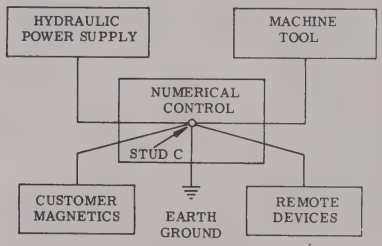
If the Multiple Input Voltage option is included, the power input circuits may be connected to accept 208, 230, 240, 380, 415, 460, 480, 500 or 575 volts, +10-15%, 50/60 Hz. Otherwise the input voltage must be 115 volts +10-15%, 50/60 Hz. Input fusing is provided in the Control. A Disconnect switch must be provided externally for the entire machine/Control site.

Refer to reference sheets 100 and 101 in the diagrams for incoming power connections.

GROUNDING

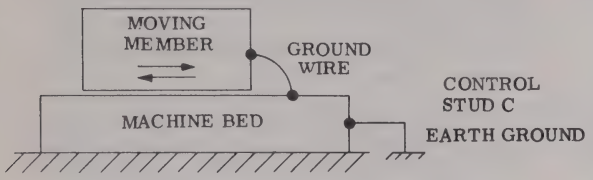
1. Make all ground connections to the Control from the machine and other components at the ground stud on the Control frame near the incoming power connections.

2. Connect the system ground in tree fashion with earth ground at the trunk of the tree. Connect the "branches" to ground at one point only, so that no ground conductor carries the current from another "branch".



3. For the main ground connections such as connections from the ground stud to the customer's earth ground or magnetics ground, use braided straps or welding cables. These straps or cables should be size AWG #8 or larger. For the individual branch grounds, use a wire which is as short as practical and large enough to carry the maximum short-circuit current of the branch as determined by the fuse rating.

4. Moving members of the machine may have to be grounded to the machine bed under certain conditions. For example, when using Accupin* transducer or Inductosyn** scales with the electronics mounted on a moving machine member, there may not be a sufficient ground to the machine bed.



5. If wireways with metal divisions are used, ground the dividers. When using screws or bolts for such applications, use them with star washers to assure a positive electrical connection.

6. In general, a good guideline to follow for the size of ground conductors is to make them as short as possible and as large in size as practical.

Earth Ground

In general, there are two distinct needs for system grounding, as outlined below:

NEED FOR GROUND*	HOW TO MEET THE NEED	EFFECT
System, Electrical Ground or Circuit Ground	Establish a neutral reference wire common to all voltage sources within the system.	Assures that all voltages have the same reference base, and limits the voltage potential in the event of circuit shorts or other malfunctions.
Equipment or Safety Ground	1. Establish a low impedance path between the equipment enclosure and other material parts of the system. 2. Establish a low-impedance path to earth.	Minimizes the exposure to personal shocks in the event of circuit shorts or other malfunction.

Inasmuch as the safety requirements may vary with geographic location, be sure to consult the local governing codes, which take precedence over the following guidelines that are, in general, considered practical. These guidelines are based on the following references:

National Electrical Code 1975
California "Electrical Safety Orders" 1967
Pennsylvania "Electrical Safety Regulations" 1965

EARTH GROUND CONNECTIONS, IN ORDER OF EFFECTIVENESS	DESCRIPTION
1. Continuous water pipe	Properly buried length, depending on condition of soil. Installed below permanent moisture level (the impedance of this type of ground is typically 3 ohms).
2. Man-made driven or buried electrodes	Properly installed length depending on condition of soil. Installed below permanent moisture level (the impedance of this type of ground is typically below 5 ohms.)
3. Other available electrodes, such as metal frames of buildings or metal well casings	Must be well chosen, since they are substantially below 25 ohms, but exceed 5 ohms.

Ground connections, wire, and electrodes should not exceed 5 ohms, as measured from the equipment ground stud through the primary electrode, through earth, to another independent electrode separated by 20 feet of earth. Additional ground should be installed when necessary to insure that the impedance does not exceed 5 ohms. The ohmic measurement should be made in terms of a voltage-current relation, such as the current of a 120-volt, 100-watt lamp bulb.

The ground conductor connecting the ground stud to the chosen electrode should be of braid or welding cable (equivalent to AWG#8 or larger). Braid or welding cable minimizes the resistance at higher frequencies.

*Trademark of General Electric Company, USA
**Registered trademark of Farrand Controls, Inc.

*"Ground" is commonly referred to as "Earth Ground", "Earth", "Ground", "Magnetics Ground", "Equipment Ground", "Electrical Ground", "Circuit Ground", "Neutral Ground", "Reference Ground", or some other appropriate term which refers to the basic term "Ground".

When longer lengths are required, use a larger size cable, so that the total resistance of the cable is less than 0.075 ohms. In general, the size must be rated to carry peak short-circuited current for maximum time duration without degrading the ground system, and must withstand any mechanical abuse to which it may be exposed.

Interconnect all separate enclosures, control stations, pendant stations, conduits,, the like, to maintain safe ground continuity throughout all metallic components of the system. To implement and continue to maintain safety ground continuity throughout all metallic components of the system is always considered good practice and a locally regulated requirement.

INTERCONNECTIONS

The wires used for customer connections between the Control and external devices (machine-mounted devices, auxiliary magnetics, the power source, etc.), fall into 2 groups as outlined in the table below.

In order to minimize problems of electrical interference, all customer connections between the Control and external devices should be made in accordance with the following procedure:

1. Arrange the interconnecting wires into groups as indicated in the following table.

2. Separate the groups by at least 12 inches of space or by magnetic shielding such as separate grounded conduits or grounded metal partitions in the wire duct.

3. Keep the wiring between the Control and remote locations as short as practical.

4. Use only wires which are of adequate size for their length to carry the current load required and to keep the voltage drop at a minimum. For example, a voltage drop of more than one volt along the wire length would be excessive for a control circuit of 28 volts.

5. In group I of the following table, run the wires as twisted pairs; i.e., twist the wire carrying current to a device with the wire carrying the same current from the device. Where several devices have one common return wire, twist all the outgoing wires with the one return wire.

6. Be sure that any wires in one group which must cross those in the other group do so at 90° angles unless they are in separate conduits.

NOTE

To find a specific circuit and the terminal point from which it is brought to the customer's connection, refer to the Installation section of the elementary diagrams.

WIRES USED FOR CUSTOMER CONNECTIONS BETWEEN THE CONTROL AND EXTERNAL DEVICES

GROUP NUMBER	WIRES INCLUDED IN GROUP	SPECIFIC EXAMPLES
I	Wires used in all power circuits	Wires to AC motors, contactors, relays, solenoids, and drive panels. Wires used in: DC motor armature circuits DC solenoids DC relays not associated with logic Other wires used for DC circuits that are not included in Group II.
II	Wires used in all signal and bus circuits	Wires used in pickup-unit cables, tachometer feedback cables, hydraulic valve cables, and wires used for Control bus voltages. Wires to logic input filters (switch inputs) and wires from logic output drivers (relays and lights driven by logic circuits).

NOISE SUPPRESSION

The customer should mount suppression circuits which are needed for the particular devices he requires. Refer to Figure 2 for noise-suppression circuits and suggested components for magnetic devices.

NOTE: General Electric suppresses all devices which are mounted in the Machine Control. General Electric also provides input filters for all externally connected circuits leading to or from the Control logic.

1. Since the General Electric Company does not have all machine devices available during factory test of the Control, the effectiveness of arc suppression supplied by the factory must be verified at the machine builder's plant as well as the ultimate user's plant.

2. Mount suppressors on or as close as possible to the terminals of the device (starter, relay, clutch solenoid, etc.) being arc-suppressed, but not more than 12 inches from the terminals.

DEVICES	SUPPRESSORS
DC devices	Diodes
AC devices	RC network and/or thyrectors
Low-current, 110-volt AC devices such as size 00 starters	A 0.5 mfd capacitor in series with a 220-ohm resistor.
High-current devices	A 0.5 mfd capacitor in series with a 220-ohm resistor, and an additional suppressor, such as a thyrector

3. Since the manner in which the various interconnecting wires are run can have a definite effect on noise pickup, be sure that these wires are essentially at the same locations during checkout at the plant of the original equipment manufacturer as they are expected to be at the ultimate user's plant.

4. Group together and position the wiring as described under Interconnections, page 6. Keep the wiring as far as possible from internal wiring associated with the static logic portion of the Control.

5. Make sure that each device energized from the operator's panel has the proper suppression device.

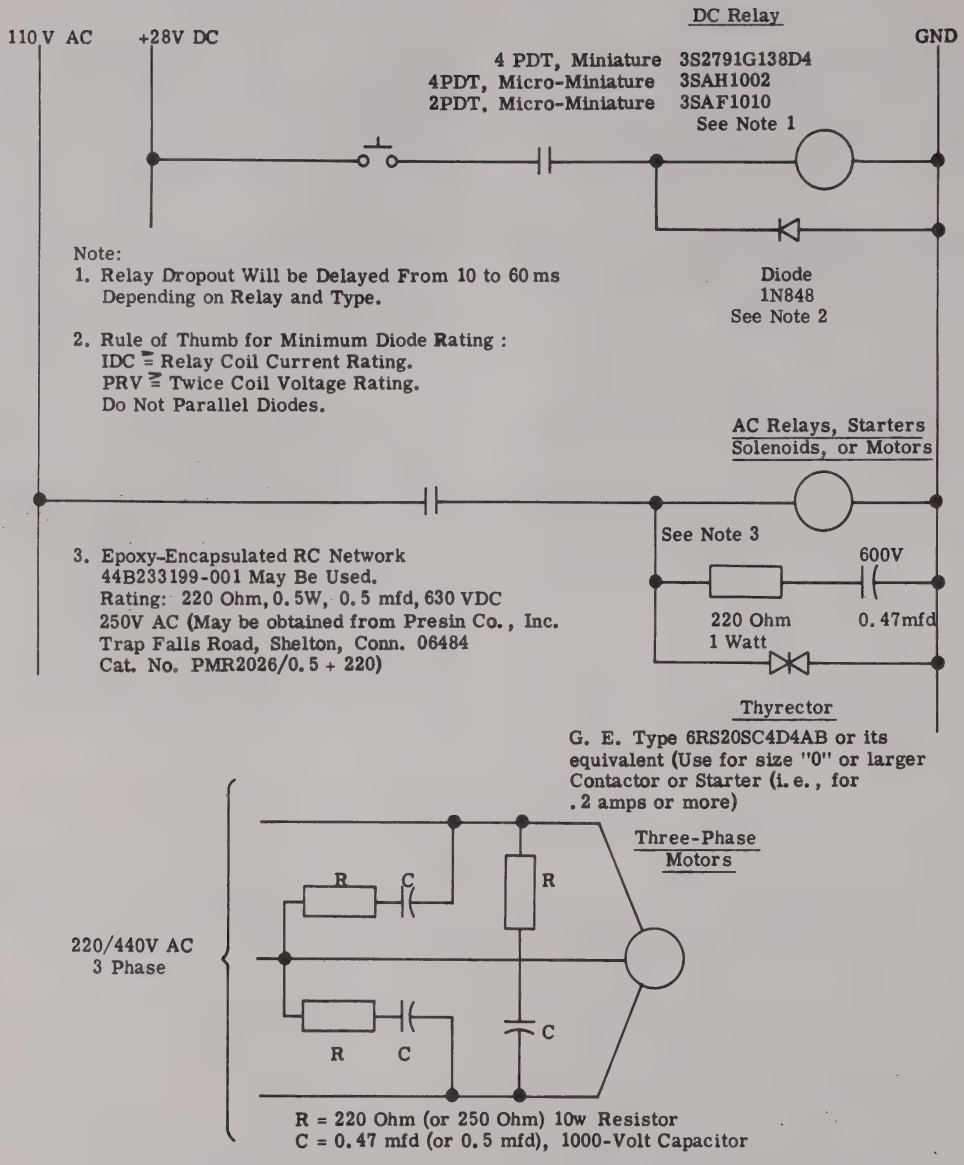


Figure 2.
NOISE SUPPRESSION CIRCUITS AND SUGGESTED COMPONENTS FOR MAGNETIC DEVICES

SHIELDING

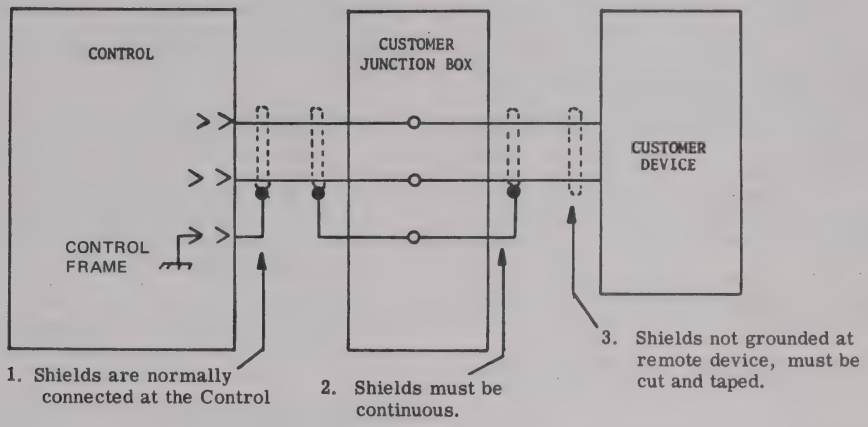
Shielded cables should be grounded at one end only per the customer connection diagrams for the individual Machine Control.

1. Cables are grounded at the Control end in most applications, but this may not always be possible.

2. Connect shields so that they are continuous. For example, if a shielded cable goes through a customer junction box, the shield must also be continued through the box.

3. If an end of a shield is not connected, insulate it with tape to keep it from touching ground or another circuit.

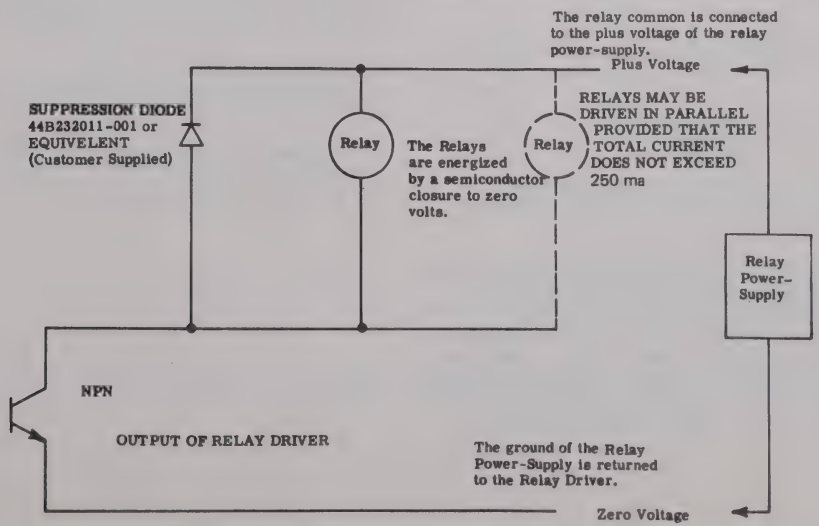
The following is an example to illustrate items 1, 2, and 3 above.



4. Two of the most critical applications for shielded cables are Accupin transducer and Inductosyn scales. The routing, grounding, and types of cables used are all critical for proper performance and noise rejection.

RELAY DRIVERS

The Control is equipped with relay drivers as shown below. These relay drivers aredesigned to perform two functions:

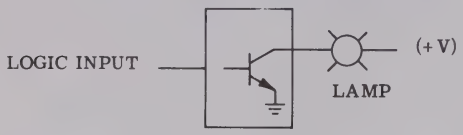


1. To drive relays with coils requiring voltage up to 28 volts DC (maximum peak of 50 volts) and current up to 250 ma.

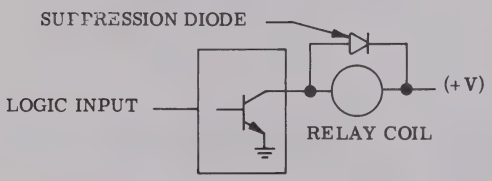
2. To drive indicator lamps requiring current up to 250 ma. (The lamps are simply substituted for the relays; neither a surge-current limiting resistor nor a suppression diode is required for driving lamps.)

Operation

The output driver is designed to convert logic commands from the computer to a level which is sufficient to drive relays and indicator lamps. The following diagrams show typical uses of the output driver.



OUTPUT DRIVER USED AS A LAMP DRIVER



OUTPUT DRIVER USED AS A RELAY DRIVER

CAUTION

Failure to supply the suppression diode can result in a malfunction of the Machine Control.

In essence the output driver acts as a switch, closing the current path through the connected device to ground. An internal filter at the input of each driver eliminates the possibility of noise entering the logic system through the driver and its load. Each driver is capable of driving a maximum load of 0.25 amps at a maximum of 50 volts. On all Controls, circuits are provided for external operation of relays and lamps with output drivers. The voltages provided are +28 volts DC for relay operation and +5.7 volts DC for lamp operation. The output driver may also be used to drive logic devices for customer static switching providing the proper pull-up resistor is used and the customer takes responsibility for filtering and synchronization with his logic. These applications should be reviewed by the Industrial Control Products Department.

Complete the Interconnection wiring per reference sheets and in the Machine Control Elementaries.

CAUTION

When inserting or removing printed-circuit boards, it is important to insure that power is disconnected from the board. The majority of boards can be plugged in or removed from the system by merely turning the Control off.

However, memory boards, battery charger and regulator boards should not be removed unless all power is removed from the system AND the batteries are switched off.

INITIAL CHECKOUT AND ADJUSTMENTS PRIOR TO APPLYING POWER

When all customer devices feedback units, motor, etc. have been installed and all interconnection wiring has been completed, the following steps should be completed prior to applying power to the Control.

1. Make a continuity check to establish that the AC input is not shorted to ground. Note that due to transformer action there will be a small resistance (3 to 5 ohms) between the AC line and ground.

2. Double-check to be certain that all customer devices have been properly noise suppressed as described in the Device Suppression section above.

3. Refer to reference sheet 900 in the Control elementaries for jumpers to be added or removed depending on required operation.

INITIAL POWER ON CHECK

The following checks should be made immediately after power is applied to the Machine Control for the first time.

When AC power is applied to the Control, the Control Off indicator should be lighted. To turn the Control on, depress the Control On pushbutton which lights the Control On and Stop indicators. All fans should start running.

1. Check and adjust, if required, all DC voltages as described in the Power Supply publication in Chapter XIV.

2. Load the executive software into memory as follows:

A. Mount the executive software tape onto the tape reader.

B. Turn the Control off (by depressing the Control Off pushbutton).

C. Turn the Keyswitch to the LOAD SOFTWARE position.

D. Hold the Store Program pushbutton depressed while depressing the Control On pushbutton.

The Control then turns on and the tape reader loads the program into memory. A Machine Setup Data tape may be spliced onto the executive tape or loaded separately. See "Machine Setup Data" in this chapter.

3. Check to be certain that all machine limit switches are wired and operating properly. This check may be made by measuring the voltage on terminal board to which the limit switch is wired. There will be +12V as measured between the limit switch plug point and ground when the limit switch is open and -12V when the limit switch is closed.

After completing the above three steps, the Control should be ready for servo adjustment. See Chapter XIII.

INDUSTRIAL CONTROL DEPARTMENT, GENERAL ELECTRIC COMPANY, WAYNESBORO, VIRGINIA

1050T MACHINE SETUP DATA

GENERAL

Machine Setup Data is entered into a Control from a punched paper tape which has the format and appearance of a part-program tape. Each block in a Machine Setup Data tape contains a Machine Setup Data code to identify the machine parameter, and may contain one or more words of data for that parameter. The Machine Setup Data code consists of the letter L followed by 4 digits. A data word consists of a letter followed by 1 or more digits. Table 1 lists all Machine Setup Data codes for the 1050T and specifies the data word to accompany each code. Every Machine Setup Data block may contain a comment enclosed in parentheses when RS-358 character coding is used.

Whenever there are several independent data items associated with a particular Machine Setup Data code, they may all be entered in one block or they may be entered in several separate blocks. For example, on a 2 axis machine, the machine reference position on each axis may be entered in one block as:

L1502 x150000 z130000

Or it may be entered in any combination of separate blocks such as:

L1502 x150000

L1502 z100000

The M word is used in a Machine Setup Data tape to indicate "Yes" or "No" and "Positive" or "Negative." M00 means No or Negative and M01 means Yes or Positive.

A Machine Setup Data tape may contain block sequence numbers (n numbers) if they are desired, and may be punched in either RS-358 code or RS-244 code.

RS-358 code requires the use of upper case letters and RS-244 requires lower case. In the examples, L is shown in upper case to avoid confusing it with the number 1.

TAPE PREPARATION

Since a Machine Setup Data tape is in a part-program-like format, it can be created and changed manually on any TermiNet* printer, Flexowriter, or similar device, that is equipped with a tape punch. A stop code is required if rewind is to be used and an end-of-block must precede the first block of data. (See Figure 1)

PROGRAMMING THE MACHINE SETUP DATA TAPE

Quantities which may be specified in a Machine Setup Data tape are listed in Table 1, page 3. If a quantity is not included in the tape, the default value will be used by the Control. The only parameters which must be programmed are at least one spindle gear range and s4 format if the CSS/Direct RPM option is used.

Trailing zeros must be programmed in all Machine Setup Data words. Leading zeros may be omitted.

NOTE

There are three order sensitive blocks.

1. The selection of the dimension word length and format becomes effective immediately. It is therefore recommended that this be the first quantity specified on the Machine Setup Data Tape if the default values are not to be used.

2. The s format should not be selected until after the MST strobe times are selected.

3. The maximum spindle speed selections for the gear ranges must come later than the s format.

The instructions for programming the Machine Setup Data for the Programmable Control Interface option are contained in GEK-36070, not included in this book.

The instructions for programming the Machine Setup Data for the Leadscrew Error Compensation option are contained in Chapter III, Options.

The instructions for programming the Machine Setup Data to Convert Display Messages to Other Languages are contained in Chapter III, Options.

The instructions for programming the Machine Setup Data for Work Surface Programming are contained in Chapter III, Options.

*Trademark of General Electric Co., USA

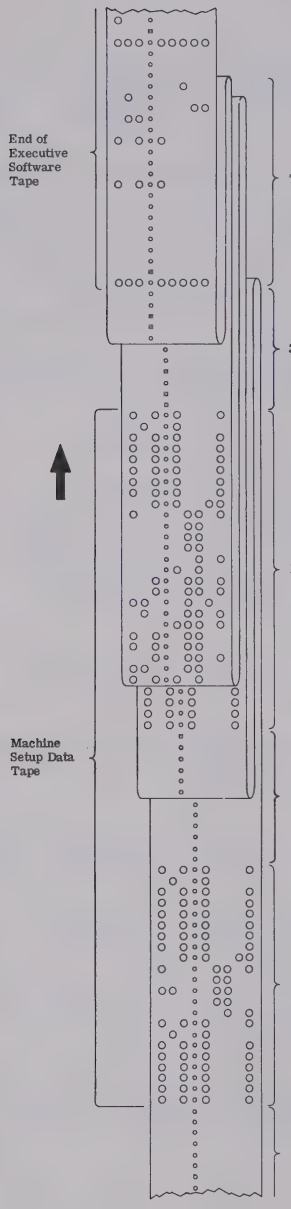


Figure 1.
EXECUTIVE SOFTWARE TAPE SPLICED WITH MACHINE SETUP DATA TAPE

NOTES:

1. The last Machine Setup Data block on every Machine Setup Data tape must contain one of the following:

CODE	MEANING
L1030	End-of-tape; Rewind
L1002	End-of-tape; No Rewind

*2. Every tape supplied by GE ends with either an L1030 or an L1002 block. The customer will normally include one of these blocks at the end of his MSD tape and discard the one supplied by GE.

3. Data blocks in the Executive Software and MSD sections of the tape supplied by GE should not be changed.

Using A Machine Setup Data (MSD) Tape

A Machine Setup Data tape can be read into a Control under the conditions that exist only immediately after the executive software is loaded, before the keyswitch is switched out of the SOFTWARE LOAD position. To simplify tape handling, the Machine Setup Data tape for a particular machine may be spliced onto the end of the executive software tape. Then it will be read in automatically without operator intervention. Before splicing on a Machine Setup Data tape, cut off the final portion of the executive tape containing an L1002 code. This is preceded by approximately 30" of sprocket holes. The cut may be made anywhere in the sprocket hole portion.

However, the reading of a Machine Setup Data tape may be initiated manually to supply complete Machine Setup Data or to change selected parameters that have already been entered. The operator can reference-zero the axes and jog the machine while the keyswitch is still in the SOFTWARE LOAD position.

Operator Procedure

Use the following procedure to load executive software and the Machine Setup Data.

1. Set the keyswitch to SOFTWARE LOAD, set the Mode selector to AUTO and set the Program source switch to TAPE.

2. Initiate the software loading process by depressing the Control On pushbutton while the Store Program pushbutton is being held depressed. (Begin with the Control off.)

3. At the end of the executive portion of the tape the power-up routine runs and certain conditions are checked. Then the Machine Setup Data function takes control.

If the Auto mode is not selected, the message SELECT AUTO MODE is displayed.

If the Program Source switch is not in TAPE, the message CHECK CONTROL SWITCHES is displayed.

When auto is in effect, a cycle start is initiated automatically and the Machine Setup Data on the executive software tape is read and processed.

An L1030 in the last block of Machine Setup Data causes the tape to rewind. An L1002 causes the tape to stop.

4. If there is an additional Machine Setup Data tape to be read, mount the tape and depress the Cycle Start pushbutton. (Any number of separate tapes can be entered this way.)

5. After all the Machine Setup Data has been entered, switch the keyswitch out of the SOFTWARE LOAD position. This causes power-up to run again and clear the Machine Setup Data routine from memory. If all of the Machine Setup Data is on the end of the executive software tape, the keyswitch may be switched out of the SOFTWARE LOAD position as soon as the software loading process has been initiated.

Table 1.
MACHINE SETUP DATA QUANTITIES FOR THE 1050T

GROUP	ITEM	MSD CODE	WORDS TO BE SPECIFIED	DATA	DEFAULT DATA (Used by Control if no data specified.)	SOFTWARE REVISION LEVEL
Option Selection	RPM/CSS Programming/ No RPM/CSS Programming	L1110	m_ _	m01 = RPM/CSS m00 = No RPM/CSS	RPM/CSS Programming	7xx C1
	Position Offsets/ No Position Offsets	L1111	m_ _	m01 = Position Offset* m00 = No Position Offset	No Position Offset	7xx C1
	CWC/No CWC	L1112	m_ _	m01 = CWC m00 = No CWC	No CWC	7xx C1
	Multiple MFO/SSO No Multiple MFO/SSO	L1113	m_ _	m01 = Multiple MFO/SSO (Change number of OD boards to 3.) m00 = No multiple MFO/SSO	No multiple MFO/SSO	7xx C8
	Enable full or partial Diameter Programming/ No Diameter Programming	L1116	m_ _	m01 = Diameter Programming m00 = No Diameter Programming	No Diameter Programming	7xx C8
	Full Diam. Prog./ Partial Diam. Prog.	L1119	m_ _	m01 = Full Diam. Prog. m00 = Partial	Partial	7xx C8
	NOTE: Diameter Programming must have previously been selected for L1119 codes to have any effect.					
	Decimal Point Programming	L1120	m_ _	m01 = Dec. Pt. Prog. m00 = No Dec. Pt.	No Decimal Point Programming	7xx D3
	NOTE: Decimal Point Programming only applies to x, z, i, k, r, and f words, so omit leading or omit trailing zeros should be selected for the other words. L1102 can be used to make this selection.					
Modes of Operation assumed after any Clear operation or Power On	g70 (Inch)/g71 (Metric) g91 (Incr.)/g90 (Absolute) g94 (ipm/mmpm) g95 (ipr/mmpr)	L1203 L1203 L1203	g_ _ g_ _ g_ _	Must be programmed in separate blocks	g70 (Inch) g91 (Incremental) g94 (ipm/mmpm)	7xx A1
Arc Direction	EIA Arc Direction	L1101	m_ _	m00 = non EIA m01 = EIA	EIA	7xx A1
Feedback System	Inch (0.1 Inch) Metric (2.0mm)	L1008 L1009	none none		Inch	7xx A1

(Continued)

*Also specify at least 3 IFI32 boards with a L1012 x 3 code; if you are using the Position Offset Limit switches.

Table 1.
MACHINE SETUP DATA QUANTITIES FOR THE 1050 T (continued from page 4)

GROUP	ITEM	MSD CODE	WORDS TO BE SPECIFIED	DATA	DEFAULT DATA (Used by Control if no data specified)	SOFTWARE REVISION LEVEL
Input Data Variations	Dimension Word Format English Metric	 L1201 L1202	 x_ _, z_ _ x_ _, z_ _	 24 or 34 33 or 43	 24 43	7xx A1
	Tool Offset Data Format English Metric	 L1901 L1902	 x_ _ x_ _	 03 (.0999 inch), 04, 14, or 24 03, 13, 23, 33 NOTE: English and Metric tool offset formats must contain same number of digits	 04 13	7xx A1
	Trailing or Leading zero omit	L1102	m_ _	m00 = Trailing m01 = Leading	Trailing	7xx A1
	Dwell in Rev or Sec in g95 mode	L1103	m_ _	m00 = revolutions m01 = seconds	Seconds	7xx A1
	4-Digit t code 3-Digit t code	L1114	m_ _	m01 = 4-digit t code TTOO m00 = 3-digit t code TOO	4-Digit t code	7xx C8
Feed, Traverse, and Jog Rates	Low Jog Rate English Metric	 L1301 L1302	 f_ _ _ _ _ f_ _ _ _ _	 Format f32 ipm f41 mmpm	 01000 (10 ipm) 02000 (200 mmpm)	7xx A1
	High Jog Rate English Metric	 L1303 L1304	 f_ _ _ _ _ f_ _ _ _ _	 f32 ipm f41 mmpm	 10000 (100 ipm) 20000 (2000 mmpm)	7xx A1
	Incremental Feed Rate English Metric	 L1305 L1306	 f_ _ _ _ _ f_ _ _ _ _	 f32 ipm f41 mmpm	 05000 (50 ipm) 10000 (1000 mmpm)	7xx A1
	Traverse Rate English Metric	 L1307 L1308	 f_ _ _ _ _ f_ _ _ _ _	 f32 ipm f51 mmpm	 10000 (100 ipm) 020000 (2000 mmpm)	7xx A1
	Dry Run Rate English Metric	 L1309 L1310	 f_ _ _ _ _ f_ _ _ _ _	Format f32 ipm (24999 max for Inch feedback) (19500 max for Metric feedback) f41 mmpm (49980 max)	 10000 (100 ipm) 20000 (2000 mmpm)	7xx A1 7xx A1
(Continued)	Tool Offset Insertion Rate	L1311	f_ _ _ _ _	f32 ipm for Inch feedback f41 for Metric feedback	05000 (50 ipm) 05000 (500 mmpm)	7xx A1

(Continued)

Table 1.
MACHINE SETUP DATA QUANTITIES FOR THE 1050T (continued from page 5)

GROUP	ITEM	MSD CODE	WORDS TO BE SPECIFIED	DATA	DEFAULT DATA (Used by Control if no data specified)	SOFTWARE REVISION LEVEL
Feed, Traverse and Jog Rates (Continued)	Traverse Code	L1313	f_ _ _ _ _	f4 program all digits*	9000	7xx A1
	f Format in IPR/MMPR mode	L1014	x_	x0 = 04 Inch/13 Metric x1 = 05 Inch/14 Metric x2 = 14 Inch/23 Metric	f04 Inch, f13 Metric	7xx C8
	NOTE: If used, this code must come after L1313 in the MSD tape.					
	MFO active in traverse in Auto mode	L1104	m_ _	m00 = no m01 = yes m01 = yes	Yes	7xx A1
Position Loop Data	In-position Zone for g21, 22, 23	L1401	x_ _ _, z_ _ _	System counts up to 255 NOTE: A system count is .0001" for Inch feedback and .002 mm for Metric feedback.	100 (.01" or .200 mm)	7xx A1
	Error limit for each axis	L1402	x_ _ _ _ _ z_ _ _ _ _	System counts up to 30000	4000 (.4" or 8 mm)	7xx A1
	Out-of-sync for each axis	L1403	x_ _ _ _ _ z_ _ _ _ _	System counts up to 30000	6000 (.6" or 12 mm)	7xx A1
Reference Zero	Reference zero absolute directions	L1501	x_ _ z_ _	Requires a sign and any non-zero number e.g. x+1 z-1	Both positive	7xx A1
	Reference zero positions	L1502	x_ _ _ _ _ z_ _ _ _ _	Absolute position at Reference limit switch	x0 z0	7xx A1
	Reference zero rate	L1503	f_ _ _ _ _	Format: f32 ipm for Inch feedback. f41 mmpm for Metric feedback.	100 ipm 1000 mmpm	7xx A1
Axis Position Data	Incremental feed up-dates position registers	L1105	m_ _	m00 = no m01 = yes	Yes	7xx A1
M, S, T Strobe	Time prior to strobe and following strobe	L1801	s_ _ _	Up to 996 milliseconds (s996) in 4 millisecond intervals)	48 msec	7xx A1
	Strobe Time	L1802	s_ _ _		48 msec	7xx A1
	t0000 causes t strobe	L1803	m_ _	m00 = no t strobe with t0000 m01 = t strobe with t0000	No t strobe with t0000	7xx D6
Spindle Characteristics	Always + for m03	L1106	m_ _	m00 = no m01 = yes	+	7xx A1
	Always + for m04	L1107	m_ _	m00 = no m01 = yes	-	7xx A1
(Continued)	Analog output determined by 2 or 3 least significant digits of s word.	L1707	s_	Specify 2 or 3	3 (Note: Ignore this item if direct RPM/CSS is used)	7xx A1

(Continued)

*For the L1313 code, f can contain only 4 digits. For example an f90000 would have to be changed to f9000; the least significant digit is dropped.

Table 1.
MACHINE SETUP DATA QUANTITIES FOR THE 1050T (continued from page 6)

GROUP	ITEM	MSD CODE	WORDS TO BE SPECIFIED	DATA	DEFAULT DATA (Used by Control if no data specified)	SOFTWARE REVISION LEVEL
Spindle Characteristics (Continued)	s word format	L1204	s_	Defines s word format 2, 3 or 4 s4 must be programmed if direct RPM/CSS option is provided.	3 (4 with CSS)	7xx A1
	Low or High range for direct RPM programming	L1109	m_ _	m00 = low range (s31) m01 = high range (s40)	High range (s40)	7xx A1
	Maximum Spindle Speed gear 1 gear 2 gear 3 gear 4 gear 5 gear 6	 L1701 L1702 L1703 L1704 L1705 L1706	 s_ _ _ _ s_ _ _ _ s_ _ _ _ s_ _ _ _ s_ _ _ _ s_ _ _ _	Format: s4 rpm for high range, s31 rpm for low range. NOTE: Maximum spindle speed selections are only for CSS/Direct RPM programming.		7xx A1
	Spindle overspeed detection 125%/137.5% or 137.5%/150%	L1108	m_ _	m00 = 137.5%/150% m01 = 125%/137.5% % of programmed spindle speed	125%/137.5% Lower limit after 800 msec delay Upper limit after 100 msec delay	7xx A1
	Spindle monitor deceleration time period	L1205	x_ _000	Specify seconds from 00 to 65 for spindle to decelerate to new speed	6 seconds	7xx C8
	M30 will stop the spindle when AUTOCYS (Automatic Program Restart) is active	L1115	m_ _	m01 = yes M30 stops the spindle m00 = no Spindle does not stop	M30 stops the spindle	7xx C8
Punching Tapes From Program Stored in Memory	Punch rate (CPSI Board strapping selects 10 or 15, and 120 or 240).	L1010	x_	e.g. x0 = 10/15 CPS x1 = 30 CPS x2 = 60 CPS x3 = 120/240 CPS	10 CPS	7xx A1
Printing Tapes From Program Stored in Memory	Number of delete codes to follow EOB for RS-358 tapes	L1003	x_	Specify number of delete codes for CR and LF time. e.g. x3 = 3 delete code after each EOB (max. 6 deletes)	1	7xx A1

(Continued)

Table 1.
MACHINE SETUP DATA QUANTITIES FOR THE 1050T (continued from page 7)

GROUP	ITEM	MSD CODE	WORDS TO BE SPECIFIED	DATA	DEFAULT DATA (Used by Control if no data specified)	SOFTWARE REVISION LEVEL
Miscellaneous	Number of IFI32 boards in Control	L1012	x_	Specify 2, 3, 4, or 5	2	7xx A1
	Number of ODI32 boards in Control	L1013	x_	Specify 2 or 3	2	7xx A1
	Reset Parity Check	L1011	none		No default value, used only when changing from RS-244 to RS-358 or from RS-358 to RS-244	7xx A1
	End Machine Setup Data tape-no rewind	L1002	none		No default value. One must be programmed.	7xx A1
	End Machine Setup Data rewind to stop code	L1030	none			

SAMPLE MACHINE SETUP DATA TAPE

```
L1203  g90                                          (At clear, assume g90)
L1203  g95                                          (At clear, assume g95)
L1201       x34       z34                           (Inch format)
L1101                                       m00     (Non-EIA arc direction)
L1901       x03                                     (English tool offset format)
L1902       x03                                     (Metric tool offset format)
L1103                                       m00     (Dwell in revolutions when in ipr/mmpr mode)
L1301                       f1500                   (English low jog rate 15 ipm)
L1302                       f3000                   (Metric low jog rate 300 mmpm)
L1303                       f16000                  (English high jog rate 160 ipm)
L1304                       f40000                  (Metric high jog rate 4000 mmpm)
L1307                       f17500                  (English traverse rate 175 ipm)
L1308                       f44450                  (Metric traverse rate 4445 mmpm)
L1313                       f99000                  (Traverse code)
L1401       x50       z50                           (In-position zone is 0.005 in.)
L1402       x3000     z3000                         (Error limit is 0.3 in.)
L1403       x4000     z4000                         (Out-of-sync is 0.4 in.)
L1501       x+1       z-1                           (Reference zero direction)
L1502       x50000    z0                            (Reference zero positions are x = 5.0, z = 0)
L1801                                 s24           (Delay in milliseconds before and after m, s, t strobe)
L1802                                 s36           (m, s, t strobe time)
L1204                                 s4            (s format)
L1701                                 s2500         (Maximum speed in gear 1)
L1702                                 s1000         (Maximum speed in gear 2)
L1703                                 s0400         (Maximum speed in gear 3)
L1704                                 s0160         (Maximum speed in gear 4)
L1030                                               (Rewind this tape)
```

INDUSTRIAL CONTROL DEPARTMENT, GENERAL ELECTRIC COMPANY, WAYNESBORO, VIRGINIA

CHAPTER II

OPERATING THE CONTROL

OPERATING THE CONTROL

This chapter contains the information necessary to operate the Control. It describes the operator's control devices, where they are located, and how they are used. Also described are the various Error/ Fault conditions and the recovery procedure for each.

Section 1, page 2, describes the various operating sequences of the Control. This section includes instructions for normal operation in each mode, the intervention sequence for variations of normal operation and part program interruption, and other operator sequences such as tool offset entry and part program setup.

Section 2, page 23, explains the Error and Fault conditions, how these conditions are indicated, how the machine responds to these, and what recovery procedure the operator should use.

Section 3, page 29, describes the operator's devices located on the control panels. All of the devices contained on the Control are listed. Other devices may be added on the Control or machine by the Original Equipment Manufacturer (OEM). These additional devices are not described in this book.

SECTION 1
OPERATING SEQUENCES

In order to make maximum use of the capabilities of the Control, the operator should become familiar with the proper operating sequences.

This section contains a description of each operating sequence and the recommended procedure for operating the Control. Also described are the sequences the operator may use to interrupt or modify the automatic execution of a part program or other machine operation in order to change a tool, check the workpiece, etc.

The steps listed in the first column are intended to be all the steps necessary to complete a given sequence. In one or two cases, i.e. AUTO, other sequences are referenced and after a short time the operator will be familiar enough with them to proceed without referring to these pages.

The visible results listed in the second column are intended to give confidence that everything is working properly up to that step and to list some of the more common error or fault indications (a complete listing of error and fault indications is contained in section 2). Some steps do not produce a visible effect. In these cases, the second column is blank. The third column provides necessary comments.

In the event that a step is performed and an unexpected visible result occurs or an expected visible result does not occur, recheck all previous steps to verify none were omitted. If that does not correct the problem, call maintenance for assistance.

In the sequences in this section, the following rules were used:

1. Pushbutton names are underlined: Cycle Start.
2. Switch names have the first letter capitalized: Display.
3. Switch positions are capitalized: PERMIT STORE.
4. Indicator lights are in single quotes: 'Over Temp.'
5. Display messages are capitalized: PROGRAM STOP.

The sequences used in this Control are listed below.

Sequence	Page
Auto	6
Control Off	3
Control On	3
Manual	5
MDI	7
MDI of Part Program into Storage	13
Message Recall	10
Part Program Delete	14
Part Program Edit	15
Part Program Punch	16
Part Program Select	14
Part Program Setup	9
Part Program Store	12
Position Offsets	11
Reference Machine (zero)	5
Reference Stop	8
Sequence Number Search	8
Single	6
Software Load (Executive and Diagnostic)	4
Tool Offset	10
Entry or Update	10
Display	11
Intervention	17
Clear	19
Emergency Stop	21
Emergency Stop Clear	21
Feedhold	17
% Feedrate	20
% Spindle Speed	20
Retrace	19
Tool Inspection	18

NOTE: A detailed procedure for operating the Control in the Auto and Single modes using tape or memory is given on pages 21 and 22. This procedure is recommended for the operator who is not familiar with the 1050T Control.

CONTROL ON

Since the turn on procedure may vary slightly with different machine users, the steps listed here are not complete in all respects. The Control operates properly at temperatures between 40° and 120°F and between 5 and 95% relative humidity. Operation outside this range must not be attempted.

Sequence	Visible Results	Comments
1. Turn on the AC power.	'Control Off' turns on. 'Stop' turns on.	
2. Push Control On.	'Control Off' turns off. 'Stop' turns off. 'Control On' turns on.	
3. Reference machine (zero). See Sequence, page 5.		

CONTROL OFF

The control may be turned off at any time with no loss of memory. Remember that when the Control is off (even if AC power is also off) battery power is still maintained for the memory.

Sequence	Visible Results	Comments
1. Push Control Off.	'Control Off' turns on. 'Control On' turns off.	Logic power is turned off, but battery power to the memory remains on.

SOFTWARE LOAD

Software Load stores the executive software or the diagnostic software into memory. To change from one set of software to the other, it is not necessary to erase the unwanted software, it is only necessary to load the desired software tape.

Sequence	Visible Results	Comments
1. Push Control Off.	'Control off' turns on. 'Control on' turns off.	
2. Turn the Software Load keyswitch to LOAD.		
3. Set Mode to AUTO.		
4. Set Program Source to TAPE.		
5. Put the Software tape in the reader with the leader under the read head.		
6. Hold Store Program depressed.		
7. Push Control On then release Store Program.	'Control off' turns off. 'Control on' turns on. The tape runs.	When loading is complete the tape will rewind if the MSD data ends with L1030.
	SELECT AUTO MODE.	If step 3 was not followed.
	CHECK CONTROL SWITCHES.	If step 4 was not followed.
	EITHER TURN OFF SOFTWARE LOAD OR LOAD MSD USING CYCLE START.	These two messages alternate at 1.5 second intervals.
8. If a new Machine Setup Data tape is to be loaded:		
A. Put new Machine Setup Data tape in the reader with the leader under the read head.		
B. Push Cycle Start.	The tape loads and the above messages reappear.	
9. When loading software is complete, turn Software Load keyswitch to OFF.	The system starts operating.	

REFERENCE MACHINE

The Reference sequence synchronizes the Control with the machine and establishes a program zero location. For most operations, the program zero is located at the machine reference or home position, but it may also be established by Grid or Set zero, or it may be moved to some location by part program commands. The program manuscript or shop practices state which zeroing method to use.

Sequence	Visible Results	Comments
1. Choose REFERENCE, SET, or GRID		Reference and Grid Zero are non-operative in the Test mode.
2. Push one or both, Zero x and Zero z.	'Zero x or Zero z' turns on.	
	If REFERENCE ZERO: The Machine runs to the Reference limit switch and stops on the next grid.	
	The position display may be preset to a number other than zero.	
	If SET ZERO: The Machine does not move. Position display is set to zero.	Any active tool offset is canceled when either axis is zeroed so it is necessary to zero both axes to maintain position.
	If GRID ZERO: The Machine runs to the nearest grid and stops. Position display is set to zero.	
	'Zero x or Zero z' turns off.	When zero is complete.

MANUAL MODE

When the Control is in the Manual mode, the operator has direct control of the movement of the machine slides. This is sometimes necessary to load and unload the workpiece and to inspect the tool or workpiece during a program. Manual moves are also used to position the tool prior to the start of a part program, to make roughing cuts, and to machine simple parts.

Sequence	Visible Results	Comments
1. Set Mode to MANUAL. -OR- Push Feedhold.	'Feedhold' turns on.	
2. Select HIGH, LOW, or INCREMENTAL FEED.		
3. Push one or more of the Jog pushbuttons (In, Out, Left, Right).	The axis moves.	
	'Incremental Feed' turns on for the duration of the move or one second.	If Incremental Feed was selected.

AUTO MODE

The automatic mode is used for normal production operation using a part program that has been checked. The part program may be on punched tape or it may be stored in the Control memory. The program is initiated by depressing the Cycle Start pushbutton, and it continues until it is stopped by the end of the program or the operator.

Sequence	Visible Results	Comments
1. Reference Machine. See Sequence, page 11.		
2. Set up the part program. See the sequence on page 9.		
3. Set Mode to AUTO.		
4. Push Cycle Start.	'Cycle Start' turns on. Program execution starts.	See Intervention, page 16, for ways to alter normal execution.

SINGLE MODE

The Single Block mode checks out the part program. The part program may be on punched tape, or it may be stored in the Control memory as selected during the part program setup sequence.

One part program block is executed each time the Cycle Start pushbutton is depressed.

Execution of each part program block is identical to operation in the Automatic mode and the same intervention sequences apply.

Sequence	Visible Results	Comments
1. Reference machine. See Sequence, page 11.		
2. Set up the part program. See the sequence on page 9.		
3. Set Mode to SINGLE.		
4. Push Cycle Start.	'Cycle Start' turns on. The program executes one block. 'Cycle Start' turns off.	See Intervention, page 16. for ways to alter normal execution.

MANUAL DATA INPUT MODE (MDI)

The MDI mode is used for machine and Control check-out and to insert simple additions or corrections in part programs. Simple machine sequences such as a tool or turret change may be programmed, but MDI is seldom used to cut parts.

Most tape inputs may be duplicated using the MDI controls. The exceptions are a block delete code, end-of-record code, and parenthetical comments.

The only difference between the MDI and Auto or Single modes is in the method of data entry. Once the data is placed in buffer, execution is the same as in the Auto or Single modes and the same intervention sequences apply.

Sequence	Visible Results	Comments
1. Set Mode to MDI.		
2. Set Display to BUFFER (EDIT) - 32-Character display. -OR- Set Display to PROGRAM (EDIT) - 256-Character display option.		
3. Enter data using Address and number keyboard.	Data entered appears on the display.	Numbers are stored and displayed as soon as entered. Check the display to be sure data is correct. To correct a mistake, push + and start the entry over.
4. Push Cycle Start.	'Cycle Start' turns on. The program executes one block. 'Cycle Start' turns off.	

SEQUENCE NUMBER SEARCH

Sequence Number Search searches forward or reverse through a part program for a particular block. When the block is located, it is placed in buffer from where it can be edited or executed.

Sequence	Visible Results	Comments
1. Set Mode to SEQUENCE NUMBER SEARCH.		
2. Enter n.		
3. Enter the sequence number using the number keyboard.	The number is displayed.	
4. Push Forward or Rewind.	Search Starts. The block is placed in buffer. STOP CODE. READ ERROR	If the sequence number is found. If the end of the program is found. If a reading error occurs.

REFERENCE STOP

Reference stop locates a restart block in a part program. The restart block is preceded in the part program by a letter "O" code in RS-244 and by a : code in RS-358.

Sequence	Visible Results	Comments
1. Set Mode to REFERENCE STOP.		
2. Push Forward or Rewind.	The search starts.	
	The block is placed in buffer.	If the reference stop code is found.
	STOP CODE	If the end of the program is found.
	READ ERROR	If a reading error occurs.

PART PROGRAM SETUP

Part Program Setup prepares the part program for execution. The part program may either be executed from a punched tape or from the Control memory.

Sequence	Visible Results	Comments
IF TAPE		
1. Set Program Source to TAPE.		
2. Set Run/Load to LOAD.		
3. Load the tape on the tape reader.		For detailed instructions, refer to Chapter XI "Tape Reader."
4. Set Run/Load to RUN.		
5. Set Mode to: MANUAL or AUTO for continuous tape search. -OR- SINGLE OR MDI for block-by-block tape search. -OR- SEQ. NO. SEARCH and enter sequence number. -OR- REFERENCE STOP		
6. Push Forward or Rewind.	The tape moves. The part program block is placed in buffer.	Tape Stop may be used to stop a search. If block-by-block, sequence number, or reference search is completed, the part program block is placed in buffer.
	STOP CODE	If the end of the program is reached.
	READ ERROR	If a reading error occurs because of: 1. No parity 2. No sprocket 3. No track 4. Double sprocket
IF MEMORY		
1. Set Program Source to MEMORY.		
2. Select the part program. (See Part Program Select, page 13).		
3. Set Mode. (See step 5 above).		
4. Push Forward or Rewind.		
	The part program block is placed in buffer.	If block-by-block, sequence number, or reference search is completed, the part program block is placed in buffer.
	STOP CODE	If the end of the program is reached.
	READ ERROR	If a reading error occurs.

MESSAGE RECALL

Message recall is used, when the Stored Message indicator light is on, to display the saved messages.

Sequence	Visible Results	Comments
1. Set Display to MESSAGE RECALL.	The display shows stored message if 'Message Stored' is on.	
2. Push Next to see if there are other messages.		32-character display only

TOOL OFFSET - ENTRY OR UPDATE

Tool Offset Entry or Update stores or modifies the tool offset values for each axis. This can be done at any time in any mode but, if Cycle Start is on, Feed-hold must be applied first.

Sequence	Visible Results	Comments
Entry or Update		
1. Set Display to OFFSET PERMIT STORE.	The display shows table of stored offset values.	
2. Enter t and offset number. -OR- Push Next to select desired offset.	32-Character display: Selected offset is displayed. 256-Character display: Selected offset is indicated by (>).	If the active offset is the one you want changed, step 2 may be by-passed.
3. Enter x and offset value, push Store. (See note.) NOTE: If the selected offset is also active, 'Store and Move' is on and Increment +, Increment - or Store and Move must be used to store an offset value and move the machine. If 'Store and Move' is on, do not use the Store pushbutton. -OR- Set Increment Size to 1 or 10 and push Increment + or Increment - to enter the offset value.	The offset value moves to the right and shows the new and the old offset. The new offset value is stored and the offset value moves back to the left. The offset value is incremented or decremented.	It is not possible to enter or increment an offset value larger than the MSD selected tool offset register size.
4. Repeat 3 above for the z axis.		
NOTE: To clear all offset values to zero, set Display to OFFSET PERMIT STORE, enter t99 and push Store and Move.		

TOOL OFFSET - DISPLAY

Tool Offset Display is used to look at the table of stored offset values to find out what each offset value is. It is not possible to change an offset value using this sequence.

Sequence	Visible Results	Comments
Interrogate 1. Set Display to OFFSET DISPLAY (ACTIVE). 2. Push Next to select desired offset. -OR- Enter t, +, and offset number.	Display shows table of stored offset values. 32-Character display: Displays selected offset. 256-Character display: Selected offset is indicated by (>).	

POSITION OFFSETS - ENTRY

The position offset value for each axis is used to preset the command position registers at the completion of each reference zero cycle.

Sequence	Visible Results	Comments
1. Set Display to OFFSET PERMIT STORE.	The display shows table of stored offset values.	
2. Enter t and 98.	The display shows t98 and the currently stored x and z position offset values.	
3. Enter x and position offset value, push Store.	The offset value moves to the right and shows the new and the old offset. The new offset value is stored and the offset value moves back to the left.	
4. Repeat 3 above for the z axis.		

PART PROGRAM STORE

Part Program Store puts a part program into Control memory. From there, it may be executed, edited, or punched out.

Sequence	Visible Results	Comments
1. Set Display to PROGRAM INDEX.		Check storage space and storage table for space available.
2. Set Program Source to TAPE.		
3. Put the tape in the tape reader. (See part Program Setup, page 9).		
4. Make sure that the Software Load keyswitch is off.		
5. Push Store Program.	'Store Program' turns on. The tape starts.	
A. If the tape does not contain a program ID, it will stop on the first block, and the message is displayed.	ENTER PROGRAM ID	
To enter a program ID:		
1. Enter $.		
2. Enter the number (up to 12 digits).		
3. Push Store Program again.	The tape restarts.	If program ID is unique, storing continues to the first stop code.
	DUPLICATE*	If program ID is not unique, storing does not continue.
	-OR-	
	MEMORY FULL	If program is too long, the partial program is erased.
	-OR-	
	READ ERROR	If a reading error occurs, the partial program is erased.
	-OR-	
	STORAGE TABLE FULL	If there are already 10 part programs in storage.
	'Store Program' turns off. The tape stops.	When storing is complete.

*Delete the stored duplicate ID program and reload.

MDI OF PART PROGRAM INTO STORAGE

MDI of part program allows the entry of a part program into storage without the use of the tape reader.

Sequence	Visible Results	Comments
1. Set Display to PROGRAM INDEX.	Index of stored part programs is displayed.	
2. Turn Edit keyswitch to EDIT.	'Part Program Edit' turns on.	
3. Set Program Source to MEMORY.		
4. Push Store Program.	ENTER PROGRAM ID.	
5. Enter ID.		$ and up to 12 numbers.
6. Push Store Program.	Index of stored part programs is displayed plus one just created.	
7. Set Display to BUFFER (Edit) - 32 character display -OR- Set Display to PROGRAM (Edit) - 256 character display option.		
8. Set Mode to MDI.		
9. Push Tape to FWD.	Display shows "N0000".	This block can be modified to be the first block of the part program using Edit procedures.
10. Add additional blocks using Edit procedures.		

PART PROGRAM SELECT

Part Program Select selects a stored part program from the program index so it may be executed.

Sequence	Visible Results	Comments
1. Set Display to PROGRAM INDEX.	The display shows the index.	
2. Enter $, +, and the Program Index number (01-10). -OR- Push Next to select desired program.	32-Character display: ID number and length are displayed. 256-Character display: pointer is moved to selected (or next) ID number.	
3. Push Select Program.	An * is displayed to the left of the index number.	
4. Set Program Source to MEMORY.		

PART PROGRAM DELETE

Part Program Delete erases unwanted stored part programs and makes the space available for additional part programs.

Sequence	Visible Results	Comments
1. Set Display to PROGRAM INDEX.	Index of stored programs is displayed.	
2. Enter $, +, and the Program Index number (01-10). -OR- Push Next to select desired program.	The > moves to the selected index number entered.	
3. Push Delete Program.	DELETED SELECTED PART PROGRAM	Repeat step 3 to delete the selected program.

PART PROGRAM EDIT

Part Program Edit is used to update and modify part programs stored in memory. Only the selected program in memory may be edited.

Sequence	Visible Results	Comments
1. Turn the Edit Keyswitch to EDIT.	'Part Program Edit' turns on.	
2. Set Display to BUFFER (EDIT) - 32-Character display. -OR- Set Display to PROGRAM (EDIT) - 256-Character display.		
3. Set Mode to MDI.		
4. Search to the desired block using Block Search or SEQUENCE NUMBER SEARCH (and return to MDI).	Block is displayed.	
5. Set Edit to the desired edit mode (DELETE BLOCK, MODIFY BLOCK, ADD BLOCK)		
6. To add a block, push Next.	The buffer clears. 256-Character display blanks.	
7. Enter data using Address and number keyboard.	Data is displayed as it is entered.	To add a slash (/) code set Address to (/) and push + To delete a slash code set address to (/) and push -.
8. Push Part Program Edit.	'Part Program Edit' Turns off and then on.	
9. Repeat 4 through 8 above for each block.		
10. Terminate edit by turning the Edit keyswitch OFF.	'Part Program Edit' turns off.	

PART PROGRAM PUNCH

Part Program Punch may be used to punch out an updated part program. The punch is mounted external to the Control. Part programs may be punched in either the RS-358 or RS-244 code.

If a terminal such as a TermiNet* printer or teletype is being used for the external punch, then a printout of the part program may be obtained as it is punched (RS-358 only).

Sequence	Visible Results	Comment
1. Set Display to PROGRAM INDEX.	Index of stored programs is displayed.	
2. Enter $, +, and the program index number. -OR- Push Next to select the desired program.	The > moves to the selected Index number.	
3. Select a punch code (RS-244 or RS-358).		Make sure the punch rate is set to agree with the MSD selected rate.
4. Set Program Source to MEMORY.		
5. Push Punch Program.	'Punch Program' turns on. Punch starts punching 12 inches of leader followed by the part program followed by 12 inches of trailer. 'Punch Program' turns off. Punch stops.	To interrupt the punch, push Punch Program again.

*Trademark of General Electric Co., USA.

INTERVENTION SEQUENCE

Intervention sequences are used by the operator to change or modify the normal execution of a part program block.

The intervention sequences listed below are typical. They are not intended to cover all possible intervention sequences, but the operator can quickly alter these sequences to meet individual requirements.

FEEDHOLD

Feedhold stops the machine axes during a part program block for tool or workpiece inspection or to allow changes in the value of a tool offset. Feedhold interrupts all moves except high or low jog, incremental feed, tool offset departure, reference or grid zero, and threadcutting. Feedhold does not interrupt a dwell. When feedhold is active, the Manual mode is forced regardless of the position of the Mode switch.

Sequence	Visible Results	Comments
1. Push Feedhold.	'Feedhold' turns on. The machine motion is as noted above.	
2. Push Feedhold again.	'Feedhold' turns off. Machine motion resumes.	

TOOL INSPECTION

Tool inspection allows withdrawal of the tool from the workpiece to inspect or change an insert or tool, measure the workpiece, etc. and then return easily and automatically to the point where the program was interrupted and continue the cut. Retrace may be used in connection with tool inspection to clear up any material left by a broken insert or tool.

Sequence	Visible Results	Comments
1. Push Feedhold.	'Feedhold' turns on.	
*2. Push Tool Inspection.	'Tool Inspection' turns on.	
3. Incremental feed or jog one axis.	The machine moves.	The length of the move is stored in memory.
*		
4. Incremental feed or jog the other axis.	The machine moves.	The length of the move is stored in memory.
*		
5. Jog to clear the work. Only 1 axis may be jogged at a time.		The total of all jog moves is stored in memory.
6. Inspect the tool.		
7. Jog to a position which will allow a straight line move to where the tool was when step 4 was completed.		
**8. Push Tool Inspection.	'Tool Inspection' flashes. 1. The tool moves at high jog to the end point of step 4. 2. The move of step 4 is reversed and executed at high jog. 3. The move of step 3 is reversed and all but the last 0.1 inch (2mm) is executed at high jog and then it is completed at the programmed feedrate. 'Tool Inspection' turns off.	% Feedrate control is active during each move.
9. Push Feedhold.	'Feedhold' turns off.	

*Retrace may be used at these points in a tool inspection sequence. If it is used after step 3, step 4 is eliminated and the move made equal to zero. After using retrace, execute the remaining steps in the tool inspection sequence.
**When retrace is combined with tool inspection, execute the moves of step 8 first and then, when Feedhold is released, execute the retrace moves.

RETRACE

Retrace may be used to back the machine axes through up to 8 blocks of the part program. This is useful in case of a broken tool (in which case the tool inspection procedure may also be used) and when editing a part program.

Multi block retrace is only allowed in the Auto mode. In the Single or MDI mode only the active block or the just completed block may be retraced. Part program blocks containing g codes other than g01, 02, 03, 21, 22, 23 or containing s, t, m, /, will stop a retrace. Threading blocks cannot be retraced.

Sequence	Visible Results	Comments
1. Push Feedhold.	'Feedhold' turns on.	If in Single or MDI, the block may be complete and 'Cycle Start' may be off.
2. Push Retrace.	'Retrace' turns on. The machine backs up to the start of the active or just completed part program block. If in Auto there is a short delay and the machine then continues to back up through the next block. If Retrace is released in the middle of a block the motion stops and the light goes out. If one of the restrictions above is encountered, the motion stops and the light goes out. In Single or MDI, the block is placed back in buffer where it can be edited. 'Retrace' turns off.	Note: Retained commands such as s, t, and m do not revert to their previous value.
3. Push Feedhold.	'Feedhold' turns off. The machine moves forward through the part program in a normal manner.	

CLEAR

Clear resets all active commands and initializes the Control to power on conditions except that machine position is not lost, and memory of the active tool offset is retained.

Sequence	Visible Results	Comments
1. Push Clear.	The current operation, whatever it is, is aborted and the Control reverts to initial conditions except machine position and tool offsets are not lost. The Control panel lights turn on and the software tape number and revision level are shown on the display.	As part of the testing procedure, all memory locations are read and checked for memory parity.

% FEED RATE

% Feed Rate changes the machine programmed feed rate. If the additional % Feedrate potentiometers option is present, the active potentiometer is indicated by an indicator light. If no indicator light is on, the main potentiometer is active.

Sequence	Visible Results	Comments
1. Adjust the % Feedrate Potentiometer to the desired setting.	The speed of the machine is adjusted to the percentage selected except during traverse moves in the Auto mode or Threadcutting. With the 256-Character display, the setting of the % Feedrate potentiometer is shown in the status display. It is not shown on the 32-Character display.	% Feed rate may be made active during traverse moves in the Auto mode by Machine Setup Data.

% SPINDLE SPEED

% Spindle Speed changes the programmed spindle speed. If the additional % Spindle Speed potentiometers option is present, the active potentiometer is indicated by an indicator light. If no indicator light is on, the main potentiometer is active.

Sequence	Visible Results	Comments
1. Adjust the % Spindle Speed potentiometer to the desired setting.	The speed of the spindle is adjusted to the percentage selected. With the 32-Character display, the actual spindle speed is shown in the active display. With the 256-Character display, the actual spindle speed is shown in the status display.	

EMERGENCY STOP

Emergency Stop immediately stops all machine movement in an emergency.

Sequence	Visible Results	Comments
1. Push Stop.	'Stop' turns on. Machine motion is stopped. The current operation, whatever it is, is aborted and the Control reverts to initial conditions except machine position and tool offsets are not lost.	

EMERGENCY STOP CLEAR

Emergency Stop Clear is used to recover from an emergency stop after the cause has been removed.

Sequence	Visible Results	Comments
1. Remove the cause of the Stop.		
2. Push Control On. If that does not remove the Stop, push Control Off and then Control On.	'Stop' turns off.	

DETAILED PROCEDURE FOR OPERATING THE CONTROL IN THE AUTO AND SINGLE MODES

The following procedure gives detailed instructions for operating the Control in the Auto Mode. The procedure for the Single Mode is identical except that in step 9 for tape or memory, set the Mode switch to SINGLE.

Sequence	Visible Results	Comments
IF TAPE 1. Set Manual/Zero to REFERENCE, SET, OR GRID.		
2. Push one or both: Zero x and Zero z.	'Zero x or Zero z' turns on. If REFERENCE ZERO: The machine runs to the Reference limit switch and stops. Position display may be preset to a number other than zero by MSD. If SET ZERO: The machine does not move. Position display is set to zero. If GRID ZERO: The machine runs to the nearest grid and stops. Position display sets to zero. 'Zero x or Zero z' turns off.	When zero is complete.
3. Set Program Source to TAPE.		
4. Set Run/Load to LOAD.		
5. Load the tape on the tape reader.		For detailed instructions, refer to Chapter XI, "Tape Reader."
6. Set Run/Load to RUN.		
7. Set Mode to: MANUAL or AUTO for continuous tape search. -OR- SINGLE OR MDI for block-by-block tape search. -OR- SEQ. NO. SEARCH and enter the sequence number. -OR- REFERENCE STOP		To position the tape for execution.
8. Push Forward or Rewind.	The tape moves. The part program block is placed in buffer. STOP CODE READ ERROR	Tape Stop may be used to stop a search. If block-by-block, sequence number, or reference stop search is completed, the part program block is placed in buffer. If the end of the program is reached. If a reading error occurs.
9. Set Mode to AUTO.		
10. Push Cycle Start.	'Cycle Start' turns on. Program execution starts.	See Intervention Sequence, page 16 for ways to alter normal execution.

Sequence	Visible Results	Comments
IF MEMORY 1. Set Manual/Zero to REFERENCE, SET, OR GRID.		
2. Push one or both: Zero x and Zero z.	'Zero x or Zero z' turns on. If REFERENCE ZERO: Machine runs to the Reference limit switch and stops. Position display may be preset to a number other than zero. If SET ZERO: The machine does not move. Position display is set to zero. If GRID ZERO: The machine runs to the nearest grid and stops. Position display sets to zero. 'Zero x or Zero z' turns off.	When zero is complete.
3. Set Program Source to MEMORY.		
4. Set Display to PROGRAM INDEX.	The display shows the index.	
5. Enter $, +, and the program index number. -OR- Push Next to select desired program.	32-Character display: ID number and length are displayed. 256-Character display: Pointer is moved to selected ID number.	
6. Push Select Program.	An * is displayed to the left of the index number.	
7. Set Mode to: MANUAL or AUTO for continuous tape search. -OR- SINGLE OR MDI for block-by-block tape search. -OR- SEQ. NO. SEARCH and enter sequence number. -OR- REFERENCE STOP		
8. Push Forward or Rewind.	The part program block is placed in buffer. STOP CODE READ ERROR	Tape Stop may be used to stop a search. If block-by-block, sequence number, or reference; search is completed, the part program block is placed in buffer. If the end of the program is reached. If a reading error occurs.
9. Set Mode to AUTO.		
10. Push Cycle Start.	'Cycle Start' turns on. Program execution starts.	See intervention, page 16 for ways to alter normal execution.

SECTION 2
ERROR AND FAULT CONDITIONS

There are numerous checks that the Control performs on itself and on information it receives from tape, the operator, and the machine. Indicator lights and display messages are used to inform the operator of many of these conditions. The outline given below contains an alphabetical listing of the messages that may be displayed, the message type, and page where it is described.

MESSAGE	MESSAGE TYPE			PAGE
	Information	Warning	Stop	
CHECK CONTROL SWITCHES	X			4, 24
DELETED	X			13, 24
DIAG. TIMER QUE FULL		X		24
DUPLICATE	X			12, 24
EITHER TURN OFF SOFTWARE LOAD OR LOAD MSD USING CYCLE START	X			4, 24
END OF PROGRAM-M02 (or 30 or MEM)	X			24
END OF TRAVEL X (or Z)		X		24
ENTER PROGRAM ID	X			12, 24
FAK R3 = XXXX PC = YYYY R2 = ZZZZ			X	24
ILLEGAL L-CODE LXXXX	X			24
ILLEGAL OR MISSING DATA LXXXX	X			24
LOSS OF FEEDBACK			X	25=
MAAU FAULT			X	25
MEMORY FULL	X			12, 25
MPE R3 = XXXX PC = YYYY R2 = ZZZZ			X	25
MOTION INHIBITED	X			25
NO MAX. RPM		X		25
NO PROGRAM SELECTED	X			25
OFFSET ERROR-ZERO MACHINE		X		25
OUT-OF-SYNC			X	25
PROGRAM STOP	X			25
READ ERROR		X		8,9,12,21,22,26
SELECT AUTO MODE	X			4, 26
SELECTED PART PROGRAM	X			13, 26
SERVO FAULT			X	26
SPINDLE OVERSPEED			X	26
STOP CODE	X			8,9,21,22,26
STORAGE TABLE FULL	X			12, 26
ZERO MACHINE	X			26
44S28XXXX-RRL MMDDYY MMDDYY	X			26

The following outline lists each message, a brief description of what probably caused the message, and a recovery procedure if one applies.

DISPLAY MESSAGE	CAUSE	RECOVERY PROCEDURE
CHECK CONTROL SWITCHES	An attempt was made to store a part program or read an MSD tape when Program Source was not in the TAPE position.	Set Program Source to TAPE.
DELETED	The indicated part program has been removed from memory.	None. Information only.
DIAG. TIMER QUE FULL	Too many items are on the diagnostic timer que. This will not happen during normal machine operation.	Push Clear and start the sequence over.
DUPLICATE	An attempt was made to store a part program with the same ID as one already in storage.	Delete the duplicate part program or change the ID of the new one.
EITHER TURN OFF SOFTWARE LOAD OR LOAD MSD USING CYCLE START (Alternating Messages)	The Executive tape has been successfully loaded and one or more Machine Setup Data Tapes may be loaded if desired.	To terminate the message turn off the Software Load key switch.
END OF PROGRAM-M02 (or 30)	The part program has been completed.	None. Information only.
END OF PROGRAM-MEM	The part program source is memory and Cycle Start was pushed when the program pointer was pointing to the stop code at the end of the part program.	Push rewind to reposition the pointer back to the start of the part program.
END OF TRAVEL X (or Z)	An End of Travel limit switch has been tripped on the indicated axis.	Set mode to Manual and Jog off the limit switch.
ENTER PROGRAM ID	An attempt was made to store a part program that does not contain a program ID.	Set Mode to MDI, Address to $, enter an ID number using the keyboard, and push Store Program.
FAK R3 = XXXX PC = YYYY R2 = ZZZZ	The software attempted to communicate with a non-existent board or an existing board failed to respond within the time limit.	Record the data XXXX, YYYY, ZZZZ. Call maintenance personnel to verify that all required boards are properly seated and to run the diagnostic tests to identify the faulty board.
ILLEGAL L-CODE LXXXX	An MSD tape is being loaded that contains an L-code not defined in the MSD section of Chapter 1. The XXXX is the illegal code.	Refer to the instructions and correct the MSD tape. Push Clear, load the corrected MSD tape in the reader and push Cycle Start.
ILLEGAL OR MISSING DATA LXXXX	An MSD tape is being loaded that contains illegal or missing data for the indicated (XXXX) L code.	Refer to the instructions in the MSD section of Chapter 1 and correct the MSD tape. Push Clear, load the corrected MSD tape in the reader and push Cycle Start.

(Continued)

DISPLAY MESSAGE	CAUSE	RECOVERY PROCEDURE
LOSS OF FEEDBACK	The position feedback from the machine has failed causing a STOP condition.	Call maintenance personnel to troubleshoot and correct the problem.
MAAU FAULT	A fault was detected on the MAAU board.	Call maintenance personnel to troubleshoot and correct the problem.
MEMORY FULL	An attempt was made to overflow the program storage area of memory by loading a part program that was too long, adding too many blocks to a part program using Edit, or storing too many subroutines. The data being stored (program, block, or subroutine) was not stored in memory.	Delete any unnecessary programs from storage to make room for the new one. Reposition the tape to the beginning and reload the program or subroutine.
MPE R3 = XXXX PC = YYYY R2 = ZZZZ	A parity error was detected when reading data from memory.	Record the data XXXX, YYYY, ZZZZ. Call Maintenance personnel to troubleshoot and correct the problem.
MOTION INHIBITED	The motion inhibit input is active.	Remove the cause of the motion inhibit condition to continue.
NO MAX. RPM	The constant Surface Speed mode (g96) was programmed before a spindle speed constraint was stored.	Program a g92 and s code to store a maximum spindle speed constraint in RPM. Then reprogram the CSS (g96) mode.
NO PROGRAM SELECTED	An attempt was made to execute a part program from memory when none was selected.	Set Display to PROGRAM INDEX and select the desired part program.
OFFSET ERROR-ZERO MACHINE	A tool offset move was interrupted by a Clear or Stop condition causing the Control to lose track of the machine position.	Rezero the machine before continuing operation.
OUT-OF-SYNC	The servo lag exceeded the error limit value and reached the out of sync limit. During threadcutting this can be caused by too high a spindle speed. If not in threadcutting this is a malfunction that must be corrected.	If in threadcutting, either lower the spindle speed or call maintenance personnel to adjust the axis servo gain. If not in threadcutting, call maintenance personnel to troubleshoot and correct the problem.
PROGRAM STOP	An m00 or m01 was executed in the part program.	None. Information only.

(Continued)

DISPLAY MESSAGE	CAUSE	RECOVERY PROCEDURE
READ ERROR	A parity or sprocket error was detected when reading part program or MSD data from tape.	Examine the tape and/or tape reader to determine the cause of the problem. If the problem cannot be determined or corrected, call maintenance personnel to troubleshoot and correct the problem.
SELECT AUTO MODE	An attempt was made to load an MSD tape with the Mode switch not in the AUTO position.	Set mode to AUTO. Loading will continue automatically.
SELECTED PART PROGRAM	An attempt was made to delete the part program from storage that is currently selected for execution.	If this program is no longer needed, push Delete Program a second time.
SERVO FAULT	The servo fault input is active causing a STOP condition.	Call maintenance personnel to troubleshoot and correct the problem.
SPINDLE OVERSPEED	The spindle feedback indicated an overspeed condition causing a STOP.	Call maintenance personnel to troubleshoot and correct the problem.
STOP CODE	A stop code was detected in a wind forward, rewind, sequence number search, or reference search operation either on tape or in memory.	None. Information only.
STORAGE TABLE FULL	An attempt was made to store a part program after 10 or 34 part programs were already in storage.	Delete one or more part programs from storage.
ZERO MACHINE	Power was just turned on or the Control was just removed from the test mode.	Do a zero operation on each axis.
44S28XXXX-RRL MMDDYY MMDDYY (software ID)	The Clear button is depressed. XXX = Control system ID RRL = Revision and modification level of the executive software. MMDDYY = Date of executive software revision. MMDDYY = Date of latest executive software modification.	Release the Clear button.

The following tables provide a list of error and fault conditions, their probable cause, and a recovery procedure.

INDICATION	CAUSE	RECOVERY PROCEDURE
Overtemperature light is on.	The interior of the Control has reached a temperature of about 155°F (68°C). The Control will continue to operate but the operator should find a convenient stopping point in the program and shut the Control down. If the interior of the Control ever reaches a temperature of about 163°F (73°C), the Control power is removed automatically. It will not be possible to turn the power back on until the temperature decreases below about 155°F (68°C).	If the air temperature outside the Control is above 120°F (50°C), stop operation until the temperature is reduced. If the air temperature outside the Control is below 120°F (50°C), there is probably a failure in the cooling system. Call maintenance personnel to correct the problem.
Processor Error light is on.	The Control processor is not cycling properly because the source power has been removed long enough to discharge the memory batteries*, resulting in loss of the executive software. A memory parity error was detected during Control data processing. A hardware failure has occurred.	Reload the executive software tape. Turn the Control power off and then perform the normal control on procedure. If the error persists, call maintenance personnel to troubleshoot and correct the problem. Follow the same recovery procedure described above. Call maintenance personnel to troubleshoot and correct the problem. When the problem is corrected, reload the Executive software and proceed with the control on operation.
Message Stored light is on	One or more messages has been stored in a display register. All messages stored in the register (maximum of 4) may be displayed by setting the Display switch to MESSAGE RECALL.	Refer to the recovery procedure for the condition displayed. When the condition no longer exists, its message is removed from the display. When none of these conditions exist, the Message Stored light goes out.

(Continued)

*The number of hours of battery support may be increased up to 72 hours by adding additional optional batteries.

INDICATION	CAUSE	RECOVERY PROCEDURE
Stop light is on.	In addition to depressing the pushbutton, a stop may be caused by several system detected faults or failures, as indicated by the display message. (Refer to the display message table, page 23 for a list of the conditions that cause a stop).	The fault condition must first be corrected before the Control will permit further machine operation. To resume operation, depress the Control On pushbutton. Since the active commands have been erased, motion cannot result until new command data is entered.
	When a stop is generated, all active commands are erased and all machine movement stops.	If the stop was caused by a system detected fault or failure, call maintenance personnel to correct the problem before recovery is attempted.
All machine motion comes to an unexpected stop and the Control power shuts off.	The customer control on interlock may have opened.	Turn the Control back on and if the situation repeats itself, call maintenance personnel to find and correct the problem.
	A Control over or under-voltage condition may have been sensed.	
	The interior of the Control may have exceeded 163°F (73°C).	Refer to Overtemperature light page 27.

SECTION 3
OPERATOR'S CONTROL DEVICES

The devices described below are located on the operator's control panel.

PUSHBUTTONS

Pushbuttons	Function	Operating Sequences Where Used
Keyboard white 0 through 9, +, -, ., /, letters	Enters data in any of the operating sequences listed.	MDI Data Entry Tool Offset Entry Part Program Edit Part Program Select Sequence Number Search
CLEAR white	Cancels all buffer and active commands except active tool length offsets. Does not clear absolute position. Reads all memory locations and checks for parity error, performs a limited amount of internal testing of the Control when the pushbutton is held depressed and causes all of the Control panel lights to turn on except Off and Stop. Reads the settings of the Reversal Error switches on the THC1 board and displays the software ID.	Intervention
CNTRL OFF (Control Off) red, lighted	Removes logic power from the Control. Lights when incoming power to the Control is on, but logic power is off.	Turn Off
CNTRL ON (Control On) green, lighted	Applies logic power to the Control. Clears the stop condition, clears the Control, and establishes servo control and initial conditions on the machine and Control. Lights when logic power is on.	Turn On Stop
CYCLE START green, lighted	Initiates execution of the part program in the Auto, Single, or MDI mode. Lights to indicate that the selected cycle is in process.	Auto Single MDI
FEEDHOLD push ON-push OFF red, lighted	Stops machine motion except during threadcutting, tool offset motion, machine reference, or when the Control is in the Manual mode. Forces the Manual mode if the current mode is Auto, Single, or MDI. Lights to indicate that feedhold is active.	Auto Single MDI

Pushbuttons	Function	Operating Sequences Where Used
INCR + INCR - (Increment +) (Increment -) yellow	These pushbuttons increment or decrement the selected tool offset. The size of the change is determined by the Increment size switch.	Tool Offset Entry Tool Offset Update
IN, OUT, LEFT, RIGHT Jog yellow	These four pushbuttons jog the selected axis in the direction selected. The axis moves at the rate or the distance selected by the Manual Control selector switch.	Manual
NEXT white	Used to step through lists of data on the display, such as tool offsets, part program index and stored messages.	Tool Offset Program Select Message Recall
OPTN STOP (Optional Stop) yellow, lighted	Allows the operator to interrupt a part program at selected points if he so desires. The programmer programs an m01 code to determine these points. The part program is resumed when the Cycle Start pushbutton is depressed. Lights to indicate that the next m01 encountered in the program will be effective. However, optional stop is cancelled if an m00, m02, or m30 is encountered prior to the m01. The Optional Stop light is also turned off anytime Cycle Start is turned off (such as the end of a block in Single or MDI).	Auto
PART PRGRM EDIT (Part Program Edit) white, lighted (optional)	Used to perform the edit change selected by the Edit selector switch. Light On Indicates that the Edit keyswitch is on and that the Edit mode is active.	Part Program Edit
RE-TRACE yellow, lighted (optional)	Causes the axis motions of the last programmed block to be retraced when running and editing a part program. It will not restore other conditions to a previous state. If the Retrace pushbutton is depressed during a feedhold condition, the partial block is retraced. The light turns on when the Retrace pushbutton is initiated and remains on until the retrace movement is complete. If the block specified no movement or a very short move, the light remains on for one second.	Intervention

Pushbuttons	Function	Operating Sequences Where Used
STOP red, lighted	Immediately stops all machine movement in an emergency. Removes power from the servos and erases all active commands. Lights to indicate a stop condition. A stop condition may be caused by any one or more of the following: 1. Depressing the Stop pushbutton located on the operator's control panel or a similar pushbutton located on the machine or pendant station. 2. Machine interlock. Such as loss of hydraulic pump contact. 3. Operation of a backup Overtravel (extreme travel) limit switch. 4. Loss of synchronism (out-of-sync) in the Control. 5. Servo overload. a. hydraulic valve overcurrent (with hydraulic drives) b. electric motor overload (with electric drives) 6. Servo drive fault: With electric drives loss of a normally closed contact (or series string of contacts) that indicates the servo drives are operational. 7. A hardware-detected fault such as: a. loss of an axis position feedback b. failure to properly step through the command computation sequence. c. loss of the system clock 8. A computer processing failure. 9. A lack of communication between the computer processor and the logic boards for a period in excess of 30 milliseconds. (If the stop condition was caused by item 8 or 9, the Processor Error indicator light will also be on).	Intervention
STORE yellow	Stores a new tool offset value without machine movement. The new value must have been previously entered via the Number keyboard.	Tool Offset Entry Tool Offset Update

Pushbuttons	Function	Operating Sequences Where Used
STORE AND MOVE green, lighted	Changes the active tool offset value and moves the machine the amount of the change. The new value must have been previously entered via the Number keyboard. Light On Indicates that the active tool offset is the one selected for update.	Tool Offset Entry Tool Offset Update
TAPE STOP red	Stops a continuous search either in the forward or reverse direction. The buffer is cleared when the search is terminated in this manner.	Part Program Setup
TOOL INSP (Tool Inspection) red, lighted (optional)	Used to enter or leave the tool inspection mode. Light On Indicates that the tool inspection mode is active and that all jog moves will be remembered in memory.	Intervention
x, z, ZERO white, lighted	These pushbuttons select the axes to be zeroed. The light goes out when the axis is at the ZERO position.	Machine Reference

INDICATOR LIGHTS

Indicator Lights	Function	Operating Sequences Where Used
DRY RUN/TEST white	A flashing light indicates that the Operation switch is in the DRY RUN position. All feed speeds in a part program are advanced to the dry run rate. A steady light indicates that the Operation switch is in the TEST position. E Stop is forced and part programs may be executed with no machine motion.	All
INC FEED (Incremental Feed) white	Lights to indicate that an incremental move is in process. The light remains on for the duration of the move or one second, whichever is longer.	Manual
MESSAGE STORED white	Indicates that there is at least one message to the operator that can be recalled to the display by setting the Display switch to MESSAGE RECALL.	All

Indicator Lights	Function	Operating Sequences Where Used
OVER TEMP (Over Temperature) white	Warning light indicates that the Control temperature is excessively high. If the temperature continues to rise above an allowable point, a second thermostat removes the Control power.	All modes
PROCESSOR ERROR white	Indicates when the Control processor is not cycling properly, a memory parity error is detected, or a low battery voltage caused loss of memory. If this light comes on, the executive software should be reloaded. If the error persists, Control troubleshooting will be required.	All modes

SELECTOR SWITCHES

Selector Switches	Function	Operating Sequences Where Used
DISPLAY 32 character Offset Permit Store Offset Display Active	OFFSET PERMIT STORE position Allows storing or updating tool offsets. OFFSET DISPLAY ACTIVE/DISPLAY position Allows viewing the stored offset data. BUFFER (EDIT) position Allows viewing and/or entering the data to be acted on next.	Display Part Program Edit MDI Tool Offset

(Continued)

Selector Switches	Function	Operating Sequences Where Used
Buffer (Edit) Active Position G Codes Message Recall Program Index 256 Character Offset Permit Store Offset Display Program (Edit) Status Message Recall Program Index	PROGRAM (EDIT) position Allows viewing the part program data for the previous block, the active block, and one or more future blocks. Allows entry of MDI or Edit information. ACTIVE position Allows viewing of the active commands and the remaining distance to go of a part program move. POSITION position Allows viewing of the current machine position relative to part program zero. G CODES position Allows viewing of all the currently active g codes. STATUS position Combines all the information in Active, Position, and G codes positions into one display. MESSAGE RECALL position Allows viewing of any retained messages. PROGRAM INDEX position Allows viewing of the index of stored part programs. Allows storing of a part program. Allows selection of a part program for execution. PROGRAM INDEX position Allows viewing of the index of stored part programs and their length. Allows storing of a part program. Allows selection of a part program for execution.	Display Part Program Edit MDI Tool Offset
EDIT Delete Block Modify Block Add Block (optional)	DELETE BLOCK Allows the deletion of a block from a part program. MODIFY BLOCK Allows modification of a block in a part program. ADD BLOCK Allows adding a block to a part program.	Part Program Edit
MANUAL/ZERO High Low Distance .0001" .001 mm .001" .01 mm .01" .1 mm .1" 1.0 mm 1.0" 10 mm 10.0" 100 mm Reference Set Grid	Selects the rate or distance to be used in the next jog operation. Selects the type of zero to be performed in the next zero operation.	Manual Machine Reference

Selector Switches	Function	Operating Sequences Where Used
MODE Man Auto Single MDI Seq. Nmbr. Search Reference Stop	MAN position Allows the axes to be moved with the Jog pushbuttons and under control of the Manual switch. AUTO position Allows continuous operation from the part program when the Cycle Start pushbutton is depressed. SINGLE position Allows block-by-block operation from the part program when the Cycle Start pushbutton is depressed. MDI position Allows the operator to insert part program data which is executed when the Cycle Start pushbutton is depressed. SEQ NMBR SEARCH position Allows the operator to insert a sequence number and search to that block using the Forward or Reverse switch. REFERENCE STOP position Allows the operator to position the program, using the Forward or Reverse switch, to a reference character (: in RS-358 or O in RS-244).	Manual Auto Single MDI Sequence Number Reference Stop

TOGGLE SWITCHES

Toggle Switches	Function	Operating Sequences Where Used
BLOCK DELETE on off	ON position The program execution omits those blocks of the program which are preceded by a block delete code (/). In the Single mode when Cycle Start is depressed, causes the Control to skip all of the blocks containing a block delete code and to stop after executing one block. OFF position Causes the program execution to ignore all block delete codes and execute each block.	Auto Single
INCREMENT SIZE 1 10	Selects the size of the increment (1 or 10) to be used to change the selected tool offset when commanded by the Increment + or Increment - pushbutton.	Tool Offset Entry Tool Offset Update

Toggle Switches	Function	Operating Sequences Where Used
TAPE Fwd Rwd	FWD position Initiates a program search, either continuous or block-by-block, in the forward direction. A continuous search is stopped by a stop code or depressing the Tape Stop pushbutton. A block-by-block search is stopped by an end-of-block code or depressing the Tape Stop pushbutton. RWD position Initiates a program search, either continuous or block-by-block, in the rewind direction. A continuous search is stopped by a stop code or depressing the Tape Stop pushbutton. A block-by-block search is stopped by an end-of-block code or depressing the Tape Stop pushbutton.	Part Program Setup

POTENTIOMETERS

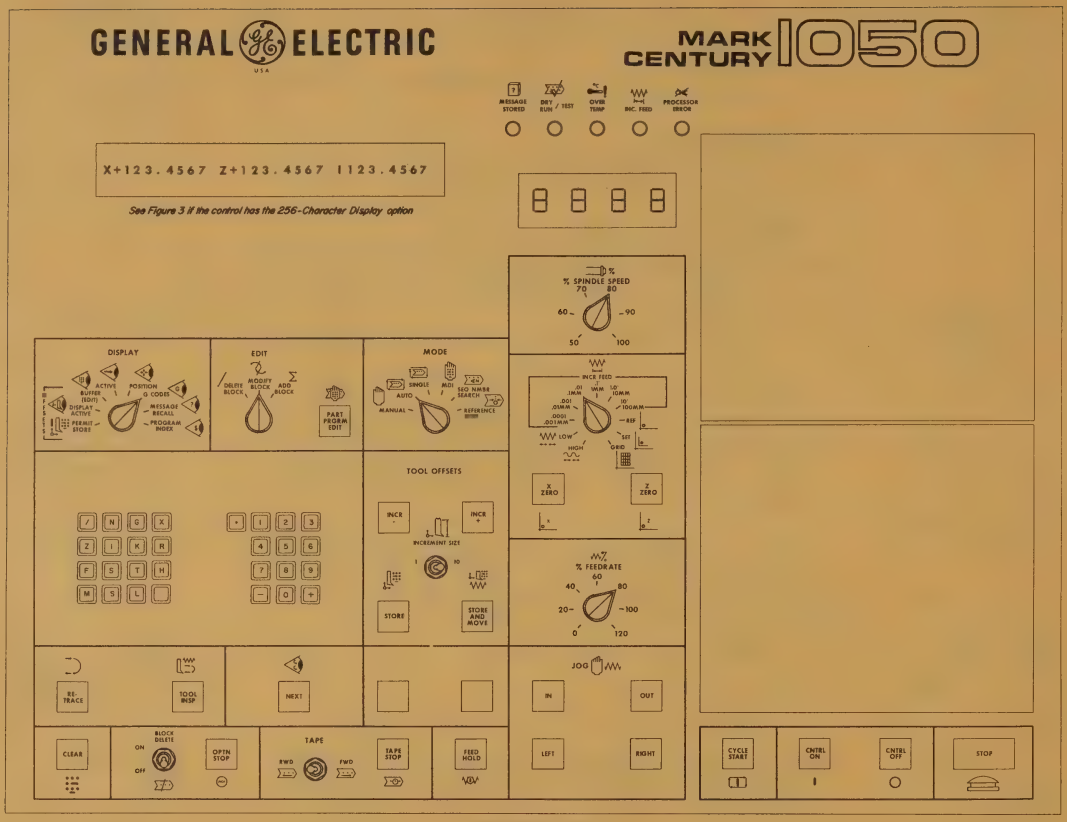
Potentiometers	Function	Operating Sequences Where Used
% FEEDRATE 0-120% (Basic)	Selects the percentage to which the programmed feed rate is changed. Active for: 1. Programmed feed moves other than threadcutting. 2. Traverse* 3. Jog 4. Incremental Feed 5. Tool Offset Insertion 6. Dry Run Not Active For: 1. Threadcutting 2. Machine Reference 3. Grid Zero When the Potentiometer is not active, the speed is automatically forced to 100%. *In the Automatic mode, % Feedrate may be made not active by a change in Machine Setup Data, page .	Intervention
Additional % FEEDRATE 0-120% (8 or 16 by option)	Allows the operator to override the programmed feed individually for each of 8 or 16 tools. The 8 or 16 controls are made active by the programmed t code xx01-xx08 or xx01-xx16 respectively. When any of these individual controls is active, the basic potentiometer is not effective.	Intervention

Potentiometers	Function	Operating Sequences Where Used
% SPINDLE SPEED 50-100% (50-120% by option)	Changes the programmed spindle speed to the percentage selected.	Intervention
Additional % SPINDLE SPEED 50-100% (8 or 16 by option)	Allows the operator to override the programmed spindle speed individually for each of 8 or 16 tools. The 8 or 16 controls are made active by the programmed t code xx01-xx08 or xx01-xx16 respectively. When any of these individual controls are active, the basic potentiometer is not effective.	Intervention

THE FOLLOWING CONTROL DEVICES ARE ON THE PANEL LOCATED DIRECTLY ABOVE THE TAPE READER

Device	Function	Operating Sequences Where Used
DLETE PROGRAM (Delete Program) yellow pushbutton (optional)	Deletes a stored program. The program number must first be selected and displayed in the readout. Operation of this pushbutton will then remove the entire program from storage.	Part Program Setup
DISPLAY OVERRIDE Toggle Switch Normal Override	NORMAL position Allows normal operation of the Display selector switch. OVERRIDE position (Chapter 9, GEK-36092, Page 16) Allows special display operation for setup and maintenance.	All Maintenance
EDIT keyswitch (optional)	EDIT position Puts the Control in the Part Program Edit mode and lights the Part Program Edit pushbutton/light. OFF position Removes the Control from the Part Program Edit mode and turns off the Part Program Edit pushbutton/light.	Part Program Edit
OPERATION Toggle switch Test Normal Dry Run	TEST position Allows normal Control operation with no machine motion. Spindle speeds are simulated based on lead for threadcutting. Dwell is always in seconds. NORMAL position Allows normal Control/machine operation. DRY RUN position Increases all feed moves (including ipr and threadcutting) to the Dry Run ipm rate while maintaining the approximate programmed path. Dry run is active only in the Auto, Single, and MDI modes. Dwell is always in seconds.	All modes

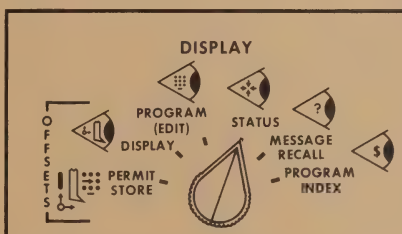
Devices	Function	Operating Sequences Where Used
PROGRAM SOURCE Toggle switch Tape Memory Remote	TAPE position Selects the tape reader as the source of part program data for execution or storage. MEMORY position Selects the Control memory as the source of part program data for execution. REMOTE position Selects a remote data source as the source of part program data for storage. (Optional)	Auto Single Part Program Setup
PUNCH CODE toggle switch RS-358 RS-244 (optional)	RS-358 position Selects RS-358 code (subset of ASCII) for the tape to be punched. RS-244 position Selects RS-244 code for the tape to be punched.	Part Program Edit
PUNCH PRGRM (Punch Program) yellow lighted pushbutton (optional)	Initiates the tape punch operation. The proper program source must be selected and the Part Program must be indicated. Light on indicates punching is in process; it turns off when punching is complete or when the lighted Punch Program pushbutton is depressed to halt the punching operation.	Part Program Edit
RUN/LOAD toggle switch (Only located on a tape reader with reels)	RUN position Prepares the reader to read tape. LOAD position Prepares the reader so that tape may be loaded.	Auto Single Part Program Setup
SLECT PRGRM (Select Program) white pushbutton (optional)	Selects a program in part program storage for execution. The desired program must have been previously chosen on the display.	Part Program Setup
SOFTWARE LOAD keyswitch	LOAD position Allows loading the system Application or Diagnostic software into memory.	Software Load
STORE PRGRM (Store Program) yellow lighted pushbutton	Initiates loading the system Application or Diagnostic software into memory if the Software Load keyswitch is in the LOAD position. Initiates storing of a part program into part program storage if the Software Load keyswitch is in the OFF position. Light On Indicates the storing of a part program in process.	Software Load Part Program Setup



MAIN CONTROL PANEL

GENERAL ELECTRIC
U.S.A.

```
SEQ NO: 1234  ID NO: 123456789ABC
TO GO:      X+123.4567   Z+123.4567
POSITION:   X+123.4567   Z+123.4567
FEED: 123.45 IPM    % FEED: 120
SPNDL: 1234RPM FWD GR1   LIM 1234
TOOL: 1234   X+.1234   Z+.1234
G: IN  ABS  IPM  RPM  01
*
```



256-CHARACTER DISPLAY OPTION

*Displays active data as determined by the Address switch.

CHAPTER III
OPTIONS AND CUSTOM FEATURES

OPTIONS FOR THE 1050T CONTROL

Options available with the 1050T are listed below. These may require hardware, software or both. When software is required, additional memory is also necessary to store the increased length executive tape.

1. Part program storage
2. Part program edit
3. Tape punch interface
4. Subroutines
5. 256-character alphanumeric display
6. Tool offsets combined with command (CWC)
7. Spindle speed override potentiometer
8. Multiple manual feedrate override (MFO) selected by t word.
9. Multiple spindle speed override (SSO) selected by t word.
10. Combined multiple MFO and SSO
11. Separate sequence number readout
12. Sequence number search
13. Constant surface speed (CSS) and direct RPM programming
14. Tape reader options
    - 5 1/4" reeler for basic 150-CPS reader
    - 150-CPS reader with 7 1/2 inch reels
    - 300-CPS reader without reels
    - 300-CPS reader with 7 1/2 inch reels
15. Machine interface options
    - Programmable machine interface
    - Standard BCD outputs
16. Servos
    - Hi-Ak* (PWM) drives
    - Hydraulic servo value amplifiers
17. Feedback devices
    - Resolvers
    - Inductosyn preamplifiers and transformers
18. Multiple tap input transformer
19. Additional battery backup for memory protection
    - Large batteries - 1 to 4
    - Larger charger for 2 to 4 batteries
20. Low voltage input for battery charging
21. Customer plugs
22. Tool inspection/retrace
23. Position offsets
24. Diameter programming
25. Decimal point programming
26. Leadscrew compensation

Description

A brief description is given below of each option. Additional details for some of these will be found elsewhere in this book.

1. PART PROGRAM STORAGE

Up to 10 part programs may be stored in memory from punched tape. Any stored part program may be executed any number of times. Pushbuttons and switches on the operator's panel may be used to operate on the stored part program in a manner similar to their use when operating with a tape. Each module of 4096 words of memory will store 8192 characters (equivalent to 68 feet of tape). Additional memory may be added to provide a maximum capacity of 81,920 characters (equivalent of 680 feet of tape).

2. PART PROGRAM EDIT

The stored part programs may be edited by adding, deleting or modifying words or blocks.

3. TAPE PUNCH INTERFACE

This option provides a tape punch interface for punching tapes from the part programs stored in memory. The electronic circuits and interface plug are in accordance with EIA Standard RS-232C. The tape punch is not included. The system elementary diagram gives wiring information for connecting to Teletype Models 33 and 35, TermiNet* printers and Facit-Addo Model 4070. A switch on the auxiliary operator's panel permits the tape to be punched with either RS-244 or RS-358 character coding.

*Trademark of General Electric Co., USA

4. SUBROUTINES

The Subroutine option permits the creation, storage and execution of customized repetitive programs such as threading, roughing, and facing operations.

The subroutines can be of two general types: those cancelled by an end of program (m02) or end of tape (m30), and those which are not. Up to 99 parametric subroutines can be identified and an individual program may be executed as many as 99 times each time it is called. Parameters stored have the same format as the word they represent and up to 16 different parameters can be used in creating the subroutines.

The subroutine option requires that the program storage option be present.

5. 256-CHARACTER ALPHANUMERIC DISPLAY

This option replaces the 32-character one-line display of the basic Control with an 8-line, 32-characters/line universal display that has expanded capability. The Display Selector switch for this option has unique switch positions that permit effective use of the larger display. These switch positions are:

Offsets - Permit Store
Offsets - Display
Program (Edit)
Status
Message Recall
Program Index

6. TOOL OFFSETS COMBINED WITH COMMAND (CWC)

This option can be specified only at the time of factory order. Thirty-two pairs of tool offsets are provided. These CWC tool offsets can be sized from 6 digits to 3 digits.

These offsets are stored, changed, incremented and displayed in the same manner as the regular tool offsets.

This option permits the x and z tool offset values to be combined algebraically with the x and z departure commands into one vectorial departure at the programmed rate.

7. SPINDLE SPEED OVERRIDE (SSO)

A Spindle Speed Override (SSO) potentiometer is provided with 2 optional ranges. These ranges are 50 to 100% and 50 to 120%.

8. MULTIPLE MANUAL FEEDRATE OVERRIDE (MFO) SELECTED BY T WORD

This option permits the operator to establish and hold different MFO settings in a group of 16 adjustable MFO potentiometers. It can be used in combination with the Multiple Spindle Speed Override option. The range of MFO setting is 0-120% of the programmed value. Indicator lights appear above each MFO switch and turn on to indicate which MFO switch is active. The first 16 tool offsets (Txx01-Txx16) call out these MFO switches. These switches are not active when the main MFO Control is active. A t00 cancels the t selected MFO and activates the main MFO.

9. MULTIPLE SPINDLE SPEED OVERRIDE (SSO)

This option permits the operator to establish and hold different SSO settings in one group of 16 adjustable SSO potentiometers. It must be used in combination with the Multiple MFO option.

10. COMBINED MULTIPLE FEEDRATE AND SPINDLE SPEED OVERRIDE

This option combines 8 MFO settings and 8 SSO settings in one option.

11. SEPARATE SEQUENCE NUMBER READOUT

An optional separate 4-digit sequence number readout is available. It displays sequence numbers from 0-9999 and can be used to identify that portion of the program being acted upon. This information is read from memory or from tape and is displayed on a separate readout panel used only for this purpose and mounted on the operator's control panel.

12. SEQUENCE NUMBER SEARCH

With the Mode switch being set at the SEQUENCE NUMBER SEARCH position, this option permits searching through the part program data for a designated block number. Search may be through the tape data or the stored part program data. The operator inputs the n number through the MDI keyboard and initiates the search with the Forward-Rewind toggle switch for either the forward or reverse direction.

13. CONSTANT SURFACE SPEED (CSS) AND DIRECT RPM PROGRAMMING

This option provides 2 ways to program spindle speed: Directly in surface feet (meters) per minute, and directly in spindle revolutions per minute. Up to 6 headstock gear ranges are permitted. The maximum spindle speed in each range is entered through Machine Setup Data. Customer input connections are provided for the gear range selection.

14. TAPE READER OPTIONS

The 5 1/4" reeler option is an add-on to the basic 150-CPS reader. This reeler accepts 6" and 7 1/2" reels, but the 7 1/2" reels should be used with this reeler only for constant data rate input.

The 150-CPS reader with 7 1/2" reels replaces the basic reader.

The 300-CPS reader is available both with and without reels.

15. MACHINE INTERFACE OPTIONS

Two options are offered.

Programmable Machine Interface

The programmable machine interface option is a small programmable controller capable of implementing efficiently those logic functions associated with non-servo machine tool requirements that have been previously performed in customer magnetics using binary coded decimal (BCD) outputs and other selected outputs from the control.

Standard BCD Outputs

The standard BCD outputs option provides BCD outputs for 2 digits of m, 3 digits of s, and 2 digits of t and outputs of m, s and t strobes.

16. SERVOS

The basic control includes the interlocking and terminal boards necessary for connection to externally mounted General Electric servo drives, either Hi-Ak (Pulse Width Modulated) or SCR. A wide range of drives are offered separately.

A 15-inch wide case extension can be supplied to the basic enclosure (left-hand side as viewed from the front) for housing the 2 axes Hi-Ak PWM Servos in various horsepower size ratings. This is a factory-supplied option and permits supplying both the 1050 CNC lathe control and servos in one integral package-factory wired and tested.

Optionally, hydraulic valve amplifies can be supplied for the following valves:

Moog Series
72 (200 ohm/15 ma, 80 ohm/40 ma)
73 (200 ohm/15 ma, 80 ohm/40 ma)
76 (200 ohm/15 ma)

Pegasus Series, 130, 131, 140, 141, 160, 161, 180, 1160, (22 ohm/200 ma)

The hydraulic valve amplifiers are mounted in an auxiliary logic rack in the Control enclosure.

17. FEEDBACK DEVICES

Resolver feedback units are available for direct coupling to standard pitch leadscrews. Gearing is 0.1 inch per revolution in the Inch system or 2 mm per revolution in the Metric system.

Inductosyn feedback options are available for the x and z axes as an alternative to the standard resolver feedback. This option provides the preamplifiers and matching transformers only. The read heads, cables and scales are to be supplied by the machinery builder.

18. MULTIPLE TAP INPUT TRANSFORMER

A multiple tap transformer provides for optional input voltages of 208, 230, 240, 380, 415, 460, 480, 500, and 575 volts, 50/60 Hz.

This transformer replaces the 115-volt, 50/60 Hz transformer supplied in the basic Control.

19. ADDITIONAL BATTERY BACKUP FOR MEMORY PROTECTION

The basic Control includes a small battery and small battery charger. An optional single large capacity battery can be used with the basic battery charger.

When 2 or more optional large batteries are used, an optional large charger is required. The following table applies:

Number of Memory Boards	Hours of Backup No. of Large Batteries 1	2	3	4	Recharge Time Hours
1	36	72	108	144	12
2	18	36	54	72	12
3	12	24	36	48	12
4	9	18	27	36	12

NOTE: Hours of Backup are a function of the number of memory boards regardless of memory size (4K-16K/board) and represent minimum time.

20. LOW VOLTAGE INPUT FOR BATTERY CHARGING

This option is provided for applications where it is desired to extend the battery support for the semiconductor memory for durations of time beyond the normal ratings of the batteries.

An optional memory power supply and battery charger panel with a 48 volt, 50/60 Hz input, is supplied to replace the standard panel. The memory power supply and battery charger is permanently connected to the 48 volt input. The main power disconnect to machine and Control can be de-energized; the 48 volt circuit to the memory power supply and battery charger remains energized.

21. CUSTOMER PLUGS

This option provides customer plugs wired to the standard terminal boards.

22. TOOL INSPECTION RETRACE

The tool inspection option permits the operator to withdraw the tool from the workpiece to inspect the part, change a tool, etc., and then return easily and automatically to the point where the program was interrupted and continue the cut. The retrace option permits the operator to retrace along the contoured path up to 8 blocks in addition to the initial block. These functions (Tool Inspection and Retrace) can be used either independently or in combination with each other.

23. POSITION OFFSETS

This option can be used on both horizontal and vertical lathes to adjust for a number of machine and process variables. It permits the independent positioning of the part program reference zero relative to the machine reference zero by operator-entered x and z position offsets. These position offsets can be made effective either from the m functions in the part program or by operator initiating the reference zero function.

24. DIAMETER PROGRAMMING

Diameter Programming allows the programmer to use diameter dimensions for x and r input. Zero should be established at the center of the workpiece.

25. DECIMAL POINT PROGRAMMING

Decimal point programming makes it simpler for the programmer or the operator to program dimension words. The decimal point establishes the number of digits to the left and right of the decimal point without being concerned with leading zeros or trailing zeros.

27. LEADSCREW COMPENSATION

Errors in leadscrew pitch and some machine misalignments which contribute to positioning inaccuracy may be compensated for by using machine setup data codes described in GEK-45691. An error table is established which allows the Control to output pulses to the machine to compensate for known machine inaccuracies.

INDUSTRIAL CONTROL DEPARTMENT, GENERAL ELECTRIC COMPANY, WAYNESBORO, VIRGINIA

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LEADSCREW ERROR COMPENSATION OPTION

Errors in leadscrew pitch and some machine misalignments which contribute to positioning inaccuracy may be compensated for by using the Machine Setup Data codes described below to store Leadscrew Error Compensation Data in the Control's memory. The data consists of a commanded position dimension and an actual position dimension (or alternatively a commanded position dimension and an error value) for those calibration points along an axis where it is necessary to change the amount of compensation.

The calibration points are uniformly spread along the axis, beginning at zero. The space between the points should be one of the calibration intervals listed with the L1691 code below. Any or all of the axes may use the leadscrew compensation feature, but all axes that are being compensated must use the same calibration interval.

The size of the table of calibration values for an axis and the zero location within that table are a function of the calibration interval chosen and the absolute dimensions of the negative-direction end of travel and the positive-direcion end of travel for that axis.

Therefore, after the leadscrew error compensation feature has been activated by establishing a calibration interval, the end of travel dimensions and the calibration interval cannot be changed without first reloading the application software (see the L1697 code for a special exception). The memory that is reserved for a compensation table comes from the memory area that is still unassigned at the time the L1692 code is read.

The following table outline explains the Machine Setup Data codes used in setting up and storing the leadscrew error compensation values.

Table 1.
Machine Setup Data Codes

MACHINE SETUP DATA CODE	DESCRIPTION
L1601	Negative end-of-travel limit for the x, z, u, w axes. Data must be programmed in system counts. The default value is -900000.
L1602	Positive end-of-travel limit for the x, z, u, w axes. Data must be programmed in system counts. The default value is 900000.
L1691	Defines the calibration interval. Program the interval number in either the x, z, u, or w word. A Machine Setup Data tape may contain more than one L1691 block (say, one for each axis), but the same interval number must be specified in all of them. Example: L1691 x10000 It is recommended that a calibration interval of 1 inch (25.4 mm or 12700 interval unit) be used. The size of the calibration interval determines the amount of memory needed to store the calibration data. An interval of 1 inch requires 1/10 the amount of memory required for a .1 inch interval.
L1692	Creates an empty calibration table or clears an existing one for each axis specified. Specify an axis by programming that axis letter and any number. The calibration interval must have been established with an L1691 block before an L1692 block is read. A block containing the L1692 code and the appropriate axis word would normally be programmed immediately in front of a set of calibration data for an axis.

(Continued)

Table 2. Machine Setup Data Codes (Continued from page 7.)

MACHINE SETUP DATA CODE	DESCRIPTION
(L1692 cont'd.)	Example: L1692 x0 (setup or initialize table for the x axis) L1693 x------k---- L1694 x---k--- L1694 x---k--- When the tape above is read the first time, the L1692 block causes a calibration table to be created for the x axis. If the first tape contains errors, it can be corrected and then read in again. If, after having loaded a calibration tape for a particular axis, it becomes necessary to put that axis back into the uncalibrated state to take new measurements, the L1692 code is used for that purpose. A complete tape for that purpose would look like this: L1692 x0 (clear the x axis table) L1696 L1002 (end of Machine Setup Data tape)
L1693	Specifies an offset in the dimension readings taken from the "actual position" measuring device to allow the zero position on the measuring device to be placed anywhere that is convenient. Program the dimension (usually zero) that will be preset into the measuring device in the k word, and the absolute (command) dimension of the setup position in the appropriate axis word. A measuring device offset is computed from this data, and it is applied to the k-word dimension in every L1694 block. The measuring device offset may be changed whenever necessary, such as at the beginning of the set of data for each axis. The initial offset value is zero. Example: L1693 x240000 k0 (setup position is at 24.0 inches on x)
L1694	Defines a calibration value by giving a commanded position and a corresponding actual position. Program the commanded position with the appropriate axis letter and program the actual position with the letter k. The commanded position must be one of the calibration points. The measuring device offset, described under L1693 above, is added to the k value and the result is subtracted from the commanded position. The final result is a calibration value which is stored in the calibration table for this axis. The calibration value must not be greater than plus or minus 0.0127 inch. Example: L1694 x130000 k-110001
L1695	Defines an error value directly, along with the corresponding commanded position. Program the commanded position with the appropriate axis letter and program the error value with the letter k. Error value = (commanded position) - (actual position)

(Continued)

Table 2. Machine Setup Data Codes (Continued from page 8.)

MACHINE SETUP DATA CODE	DESCRIPTION
(L1695 cont'd.)	The error value must not be greater than plus or minus 0.0127 inch or 127 interval counts. 127 interval counts equal .254 mm. Example: L1805 x130000 k-3 (or 0.0003 inch) The commanded position must be one of the calibration points. L1695 and L1694 blocks may be intermixed in a compensation tape.
L1696	End compensation table for one axis.
L1697	Cancels all previous leadscrew compensation data so that interval size and axis ends of travel data can be changed. This code is intended for use during the machine setup period when it may be necessary to try more than one increment size or to adjust other parameters in order to obtain the best accuracy. This code should be considered to have a temporary effect since all the existing tables will continue to occupy memory space. The permanent fix is to reload the application software and then load the final version of the leadscrew error compensation data. Program this code in a block by itself. This code moves STGMAX pointer back to the top of memory. This can cause a conflict in controls containing PCI so the PCI MSD tape must be reloaded if L1697 code is used.

Table 3.
Example of Programming Leadscrew Compensation

	x		z		u		w	
	IN	MM	IN	MM	IN	MM	IN	MM
%								
PRESET NEGATIVE END OF TRAVEL								
L1601X0Z-50000U0W0	0	0	-5.0000	-100.000	0	0	0	0
PRESET POSITIVE END OF TRAVEL								
L1602X100000Z50000U100000W100000	10.0000	200.000	5.0000	100.000	10.0000	200.000	10.0000	200.000
ESTABLISH CALIBRATION INTERVAL								
L1691X10000								
ESTABLISH CALIBRATION TABLES								
L1692X0Z0U0W0								

		INCH	MILLIMETER
L1695X0K0	X CALIBRATION VALUE	= 0 at X = 0	0 at X = 0
L1695X10000K10		= .0010 at X = 1.0000	.020 at X = 20.000
L1695X20000K20		= .0020 at X = 2.0000	.040 at X = 40.000
L1695X30000K30		= .0030 at X = 3.0000	.060 at X = 60.000
L1695X40000K40	ESTABLISH X	= .0040 at X = 4.0000	.080 at X = 80.000
L1695X50000K50	CALIBRATION VALUES	= .0050 at X = 5.0000	.100 at X = 100.000
L1695X60000K60		= .0060 at X = 6.0000	.120 at X = 120.000
L1695X70000K70		= .0070 at X = 7.0000	.140 at X = 140.000
L1695X80000K80		= .0080 at X = 8.0000	.160 at X = 160.000
L1695X90000K90		= .0090 at X = 9.0000	.180 at X = 180.000
L1695X100000K100		= .0100 at X = 10.0000	.200 at X = 200.000

END OF CALIBRATION VALUES FOR X
L1696

L1695Z-50000K-50	Z CALIBRATION VALUE	= -.0050 at Z = -5.0000 = -.100 at Z = -100.000
L1695Z-40000K-40		
L1695Z-30000K-30		
L1695Z-10000K-10	ESTABLISH Z	
L1695Z0K0	CALIBRATION VALUES	
L1695Z10000K10		
L1695Z20000K20		
L1695Z30000K30		
L1695Z40000K40		
L1695Z50000K50		

END OF CALIBRATION VALUES FOR Z
L1696

L1693U100000K0	When using L1694, add offset value programmed using L1693 to K value of L1694 and subtract from departure value.
L1694U0K-100000	
L1694U10000K-89990	
L1694U20000K-79980	
L1694U30000K-69970	
L1694U40000K-59960	For first L1694 value K = -10.0000 so add -10.0000 + 10.0000 = 0 . Subtract this value (0) from the U value of 0 to get calibration value of 0.
L1694U50000K-49950	
L1694U60000K-39940	
L1694U70000K-29930	
L1694U80000K-19920	For second L1694 value K = -8.9990 + 10.0000 = 1.0010 U = 1.0000 -1.0010 = -.0010 calibration value
L1694U90000K-9910	
L1694U100000K100	

ESTABLISH U CALIBRATION VALUES

END OF CALIBRATION VALUES FOR U
L1696

L1695W0K0	
L1695W10000K10	
L1695W20000K20	
L1695W30000K30	
L1695W40000K40	
L1695W50000K50	
L1695W60000K-60	
L1695W70000K-70	
L1695W80000K-126	

ESTABLISH W CALIBRATION VALUES

END OF CALIBRATION VALUES FOR W
L1002
CANCEL LEADSCREW COMPENSATION, BUT DOESN'T CLEAR TABLES
L1697
L1030

RECOMMENDED PROCEDURE FOR DETERMINING AND ENTERING COMPENSATION DATA

This procedure assumes negligible servo deadband.

After loading the application software tape and any other Machine Setup Data tapes, leave the switch in the SOFTWARE LOAD position, and follow this sequence.

1. Reference zero the axes to insure zero is located.

2. Select one of the allowable calibration intervals (see the L1691 code, page 7).

3. Read-in a Machine Setup Data tape containing the following:

L1691 x---	Define the interval
L1002	End Machine Setup Data tape

4. Choose an axis reference point (where compensation will be zero) and record the axis position register and the measuring device (laser, etc.) indication at this point.

5. Select the 1.0 inch incremental jog position on the Manual switch and depress either of the Jog pushbuttons for the axis once. This assumes a desired calibration interval of 1.0 inch.

6. Now each subsequent push of the Jog pushbuttons will cause the axis to move one calibration interval. A table of commanded position versus measuring device indication can now be compiled over the entire axis travel.

7. A Machine Setup Data tape should now be made as follows:

L1692 x0		(set-up x table)
L1693 x0----	k0----	(set-up offset)
L1694 x1----	k1----	
L1694 x2----	k2----	
		etc. - continue L1694 blocks
L1696		(end data for that axis)
L1002		(end Machine Setup Data tape)

The commanded position is programmed after the appropriate axis letter (x, z, u, w) and the corresponding measuring device indication is programmed in the k word.

As an alternative during step 6 above, the deviation (commanded-actual) at each position can be recorded. Then in step 7, all L1694 blocks become L1695 and the deviation is programmed in the k word.

Whichever alternative is selected above, it is only necessary to program those points at which the active compensation should change. That is, unless the amount of compensation at a given calibration point is specified, the previous amount will remain in effect.

NOTE

After calibration data has been read into the Control, the axis must be referenced (reference zero) before the calibration data will be used correctly by the Control.

INDUSTRIAL CONTROL DEPARTMENT, GENERAL ELECTRIC COMPANY, WAYNESBORO, VIRGINIA

CONVERTING DISPLAY MESSAGES TO OTHER LANGUAGES BY USING MACHINE SETUP DATA

Machine Setup Data can now be used to change English messages that appear on the display to another language. Each English message has been assigned an L code (L1209x02 through L1209x53). Either one message may be assigned to a particular L code or several messages may be assigned to one L code. Information on how to use Machine Setup Data codes which contain one message is given below.

L CODES WHICH CONTAIN ONLY ONE MESSAGE

The following L codes contain only one message:

L1209x02 through L1209x32
L1209x41
L1209x42
L1209x49 through L1209x53

To have the messages covered by the above L codes translated into another language, use the appropriate L code followed by the translated message. Table 1 on page 2 gives the L code assignment and the maximum number of characters available for the translated message.

If spaces are desired between words to make the message easier to read, a character must be left blank for each space. In other words, each space uses one of the available characters, and the space character must be included as part of the message. The message must be enclosed by parentheses; however, the parentheses do not use any of the available characters.

Messages in any language can be displayed using the ASCII characters shown in GEK-36040, Figure 7, included in the 1050 instruction book. The only restriction is on the number of characters available for each message, as shown in Table 1. Tables 2 through 5 show messages in German, French, Italian, and Swedish.

Examples

The MSD code for the first two messages in Table 1 (DIAG. TIMER QUE FULL) and (SERVO FAULT) are shown below, first in German and then in French.

German: L1209x02 (FEHLERZAEHLER VOLL)
L1209x03 (FEHLER IM VORSCHUBANTRIEB)

French: L1209x02 (DONNEES ILLEGALES OU ABSENTES)
L1209x03 (DEFAILLANCE ASSERVISSEMENT)

L Codes Which Contain Only One Message But Which Have Other Restrictions

The following L codes which also contain only one message have the following restrictions. Space characters must be included exactly in the same character position where they are shown below (represented by deltas) and zeros must be included exactly in the same character position where they are shown. Remember that a parenthesis must precede and succeed each message. These parentheses do not use any of the available characters.

Message	Maximum Characters
L1209x36(TOOL:△)	6
L1209x37(ABS△)	4
L1209x38(LAG△)	4
L1209x40(MEM△)	4
L1209x43(0A0B0S)	6
L1209x44(0I0N0C)	6
L1209x45(0△0△0P0M)	8
L1209x46(0△0△0P0R)	8
L1209x47(0R0P0M)	6
L1209x48(0C0S0S)	6

CODES THAT CONTAIN MORE THAN ONE MESSAGE

All L codes that contain more than one message are listed below with the format that must be used. Space characters must be included exactly in the same character position where they are shown below, represented by deltas (△). For the individual messages, space characters may be used in any of the available character positions for ease of reading within a message. In the examples below, these optional space characters are represented by ∅. The individual messages within a single L code are delineated below by brackets (⌣). The number of characters required for each message is shown below the bracket. In the event that the translated message requires fewer characters than the English message, space characters must be inserted in the unused character positions.

L1209x33 (SEQ∅N0:△△ID∅N0:△T0∅GO:∅∅∅△)
8 8 10

L1209x34
(POSITION:△ FEED:△ IPM△ IPR△ MMPMMMPR)
10 6 4 4 4 4

L1209x35
(FEED:△ SPNDL:RPM△ FWD△ REV△ GRLIM△)
6 6 4 4 4 2 4

L1209x39 (PRG△CHARSPACE∅AVAILABLE:)
4 4 16

Table 1.
CHARACTERS AVAILABLE FOR MESSAGES

CODE	MESSAGE	MAXIMUM CHARACTERS
L1209x02	(DIAG. TIMER QUE FULL)	30
L1209x03	(SERVO FAULT)	26
L1209x04	(MAAU FAULT)	22
L1209x05	(LOSS OF FEEDBACK)	28
L1209x06	(OUT-OF-SYNC)	24
L1209x07	(MEM ERR)	08
L1209x08	(FALSE AK)	08
L1209x09	(READ ERROR)	16
L1209x11	(END OF TRAVEL)	24
L1209x12	(PUNCH FAULT)	24
L1209x13	(PROGRAM STOP)	20
L1209x14	(END OF PROGRAM)	26
L1209x15	(NO. MAX. RPM)	32
L1209x16	(CHECK CONTROL SWITCHES)	28
L1209x17	(DUPLICATED)	32
L1209x18	(ENTER PROGRAM ID)	26
L1209x19	(MEMORY FULL)	20
L1209x20	(MOTION INHIBITED)	26
L1209x21	(SELECTED PART PROGRAM)	32
L1209x22	(ZERO MACHINE)	22
L1209x25	(STORAGE TABLE FULL)	30
L1209x26	(STOP CODE)	12
L1209x27	(DELETED)	18
L1209x29	(NO PROGRAM SELECTED)	28
L1209x30	(OFFSET ERROR-ZERO MACHINE)	32
L1209x31	(SPINDLE OVERSPEED)	28
L1209x32	(SUBROUTINE ERROR)	28
L1209x41	(WITH FEEDHOLD ON, PUNCH PCI MEM)	32
L1209x42	(ILLEGAL HEX DIGIT)	28
L1209x49	(SELECT AUTO MOFE)	28
L1209x50	(EITHER TURN OFF SOFTWARE LOAD)	32
L1209x51	(OR LOAD MSD USING CYCLE START)	32
L1209x52	(ILLEGAL L-CODE)	22
L1209x53	(ILLEGAL OR MISSING DATA)	26

Table 2.
DISPLAY MESSAGES - GERMAN

FEHLERZAEHLER VOLL
FEHLER IM VORSCHUBANTRIEB
STECKKARTE MAAU DEFEKT
WEGMESS-SYSTEM GESTOERT
SYNCHRONISATIONSFEHLER
MPE
FAK
LESEFEHLER
WEGBEGRENZUNG ANGEFAHREN
STANZFEHLER
PROGRAMMIERTER HALT
PROGRAMMENDE
GRENZDREHZAHL V. KONST. FEHLT
LOCHBANDBETR./AUTO ANWAEHLEN
PROGR.-IDENT. BEREITS VORHANDEN
PROGRAMM-IDENT. EINGEBEN
SPEICHER VOLL
BEWEGUNGSFREIGABE GESPERRT
ANGEWAEHLTES PROGRAMM LOESCHEN?
NULLPUNKT ANFAHREN
ZU VIELE TEILE-/UNTERPROGRAMME
STOP-CODE
PROGRAMM GELOESCHT
PROGRAMM ANWAEHLEN
WKZ. KORR. FEHLER NULLPUNKT ANF.
SPINDEL-UEBERDREHZAHL
UNTERPROGRAMM-FEHLER
MIT VORSCHUBHALT PCI AUSSTANZEN
FALSCHE HEX ZAHL
AUTO ANWAEHLEN
SOFTWARE LADEN ABSCHALTEN ODER
MED MIT ZYKLUS START LADEN
FALSCHER MED-BEFEHL
FALSCHE / FEHLENDE MED-DATEN

Table 3.
DISPLAY MESSAGES - FRENCH
1050T TRANSLATION

DEFAILLANCE ASSERVISSEMENT
DEFAILLANCE CARTE MAAU
PERTE DES SIGNAUX DE MESURE
PERTE DE SYNCHRONISATION
MPE
ACI
ERREUR DE PARITE
SUR FIN DE COURSE
DEFAILLANCE PERFORATRICE
SUR CODE STOP
FIN DE PROGRAMME SUR CODE
VITESSE LIMITE DE BROCHE ABSENTE
SELECTEUR SUR TAPE
DOUBLE EMPLOI
ENTRER LE NOM DU PROGRAMME
DEBORDEMENT MEMOIRE
DEPLACEMENT INHIBE
PROGRAMME SELECTIONNE
FAIRE ZERO MACHINE
DEBORDEMENT LISTE PROGRAMMES
CODE STOP
PROGRAMME DETRUIT
AUCUN PROGRAMME SELECTIONNE
PERTE CORRECTEUR - REFAIRE ZERO
BROCHE EN SURVITESSE
ERREUR DANS SOUS-PROGRAMMES
AVEC SUSP AVANCE, PERFORER PCI
DIGIT HEXADECIMAL ILLEGAL
SELECTEUR DE MODE SUR AUTO
TOURNER LA CLEF SOFTWARE LOAD
OU CHARGER LA MSD (CYCLE START)
CODE "L" ILLEGAL
DONNEES ILLEGALES OU ABSENTES

Table 4.
DISPLAY MESSAGES - ITALIAN

INFO DIAGN IN ATTESA ECCEDENTI
SERVO GUASTO
GUASTO SU MAAU
PERDITA RETROAZIONE
PERDITA SINCRONISMO
EPM
RNA
ERRORE LETTURA
FINE CORSA
GUASTO SU PERFORATORE
STOP PROGRAMMA
FINE PROGRAMMA
ASSENZA LIMITAZ VEL MANDRINO
VERIF SELETT CONTROLLO
DUPLICATO
INTRODURRE ID PROGRAMMA
MEMORIA COMPLETA
INIBIZIONE MOVIMENTI
PROGRAMMA SELEZIONATO
AZZERARE MACCHINA
INDICE MEM PROGRAMMI COMPLETO
CODICE STOP
CANCELIATO
PROGRAMMA NON SELEZI ONATO
ERRORE CORR UT AZZERARE MACCHINA
SOVRAVELOCITA MANDRINO
ERRORE SUBROUTINE
ATTIV ARR AVANZ E PERF MEM PCI
CIFRA HEX ILLEGALE
SELEZIONARE FUNZ AUTOMATICO
DISATTIVARE SELETT INTR SOFTWARE
O CARICARE MSD CON CYCLE START
CODICE-L ILLEGALE
INFO ILLEGALI O MANCANTI

Table 5.
DISPLAY MESSAGES - SWEDISH

DIAGN. KOETIDSRAD FULL
SERVOFEL
MAAU - FEL
AATERKOPPL. SAKNAS
UR SYNKRONISM
PARITETSFEL I MINNET
FALSK INFO
LAESFEL
GRAENSLAEGE
STANS - FEL
PROGRAM - STOPP
PROGR:S SLUT-M
MAX VARV-PER-MIN. SAKNAS
KOLLA STYRN:S SWITCHAR
DUBBEL ID
VAEJ PROGR:S ID
MINNET FULLT
ROERELSESTOPP
VALT DELPROGRAM
NOLLSTAELL MASKINEN
LAGRINGSTABELL FULL
STOPP - KOD
RADERAT
PROGRAMVAL SAKNAS
KOMP:SFEL - NOLLSTAELL MASKINEN
OEVERHASTIGHET PAA SPINDLEN
SUBRUTIN - FEL
FEEDHOLD PAA STANSA UT PCI MINNET
FEL. HEX-SIF.
VAELJ AUTO MODE
KOPPLA IER. SOFTWARE LOAD ELLER
LADDA MSD MHA CYCLE START
FELAKTIG L-KOD
DATAINFO FELAKTIG ELLER SAKNAS

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WORK SURFACE PROGRAMMING OPTION
(with Tool Nose Radius Compensation)
for the
1050T CNC Control

NOVEMBER, 1978

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WORK SURFACE PROGRAMMING OPTION (with Tool Nose Radius Compensation) for the 1050T CNC Control

The purpose of the Work Surface Programming option is to:

- Allow the programmer to program as if he were using a zero radius tool (sharp point), or program with a discrete radius and allow the operator to use a different radius.

- Allow the programmer to program the actual movements of the tool tip and the actual surface of the workpiece without taking the tool dimensions into account. This simplifies the process of manual programming significantly, since no complex and repetitive calculations have to be performed.

- Allow the operator to change the tool nose radius during the checkout cycle to obtain an optimum suface of the part.

- Allow tooling changes on the shop floor without changing the program, even for computer-prepared part programs without rerunning the part program on the computer.

The part programmer for NC Lathes has a calculation task before him.

The calculations may be classified into four categories:

1. Reference Points
2. Tooling Data
3. Path Computation
4. Cutting Speed

The General Electric 1050T CNC Work Surface Programming with Tool Nose Radius Compensation feature reduces the complex and repetitive calculation of the tooling data and the path computation.

The tooling data file in the Work Surface Programming feature eliminates the computation task of translating the turret or tool holder reference point to the center of the tool nose radius for different tools. This allows the programmer to program his part with the same tool reference point without taking into account lengths of different tools.

The tool nose radius compensation associated with the Work Surface Programming feature reduces the complex path computation into a straightforward programming procedure. It eliminates the calculation of the compensation path due to the tool nose radius. It also allows the programmer to use the same program for different tool nose radii without rewriting the program. This speeds up the checkout cycle of the part program.

GENERAL TOOLING

Except for some special tools, e.g., threadcutting and plunging tools, all turning tools have a tool nose radius.

The tool tip is a partial arc; thus, the cutting range is limited to a clearly defined area. This area can be determined in degrees or quadrants.

Every tooling system - regardless of whether it is a turret, tool changing, or single tool system - has a tool dimension reference. All tools are adjusted to or measured from this reference.

Each tool is measured (or adjusted) and the tool tip is specified by the distance from the tool setting zero.

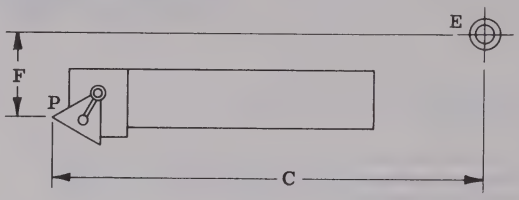


Figure 1.

NOTE
Q and L are also used instead of F and C.

E = Zero reference of the tool setting device.
F or Q = Distance of the tool tip in axis no. 1 (width).
C or L = Distance of the tool tip in axis no. 2 (length).
P = Tool tip.

There may be a distance from the tool zero reference to the center of the turret or tool holder, but this is a constant.

With the Tool Nose Radius Compensation feature, the programmer can program the part as if he were cutting with the tool tip (see Figure 2) or the point defined by the center of the tool radius. The Control will make the necessary trigonometric calculations and offset the tool path based on the nose radius of the tool used.

All tools are referenced to the tool tip "P".

Examples of the tool tip are shown in Figure 2.

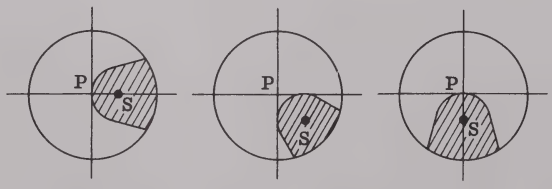


Figure 2.

Tool tip "P", also called "imaginary tool tip," is the intersection of the tangents to the arc of the tool tip, parallel to the x- and z- axis.

This overview shows that the Control needs the following tool tip information:

- Tool dimensions (F and C or Q and L dimensions)
- Tool nose radius dimension
- Tool tip location (tool orientation)

TOOL TIP LOCATION CODE

The part programmer programs either the path of imaginary tool tip "P" or the center of the tool nose radius. The Control, however, calculates and generates the path of the tool tip radius center point "S" offset by the actual radius.

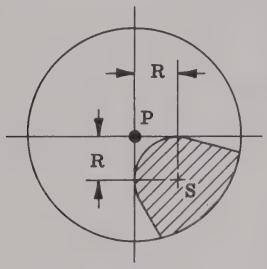


Figure 3.

If the programmer programs with the imaginary tool tip "P" instead of the tool nose radius center, the difference between the imaginary tool tip and the tool tip center point is an offset whose magnitude is the radius. The direction of the offset for each axis depends on the orientation of the tool in respect to the two axes.

Even with the wide variety of tools used on lathes the orientation of the tool can be generalized to 9 typical locations which are represented by 9 different tool tip location codes.

The location codes, numbered from 0 to 8 are defined as follows:

Location Code "0"

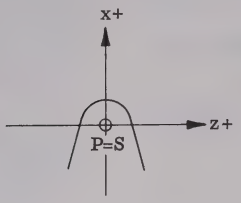
The imaginary tool tip is the center of the tool nose radius.

Location code 0 is used whenever the programmer programs with the center of the tool nose radius.

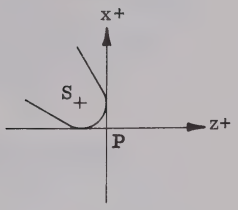
The designations, one through eight, define the location of the imaginary tool tip "P" with respect to the tool tip center point "S".

The center of the tool nose radius

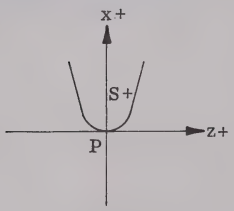
Location Code "0"



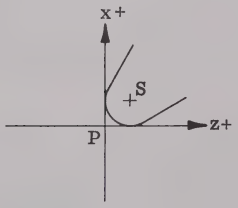
Location Code "1"



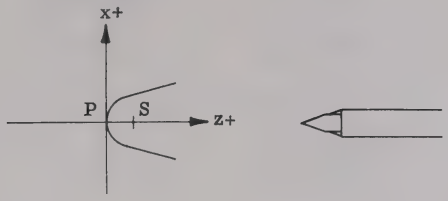
Location Code "2"



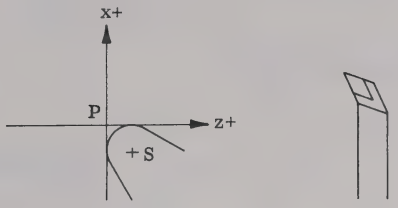
Location Code "3"



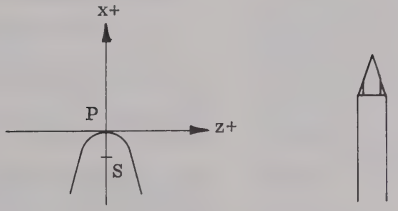
Location Code "4"



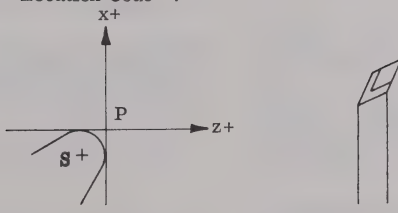
Location Code "5"



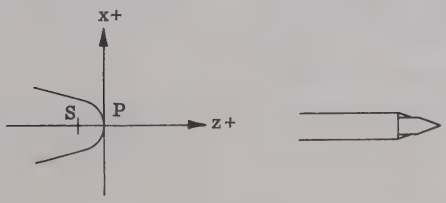
Location Code "6"



Location Code "7"



Location Code "8"



TOOLING DATA FILE

The Tooling Data File associated with the 1050T Work Surface Programming with Tool Nose Radius Compensation feature allows the programmer to program as if the tool tip is almost anywhere in space, e.g., at the center of the turret; at the reference point on the tool holder; etc. The actual x and z distance between the tool tip and the tool reference point translates the programmed tip to the actual cutting tip. The x or z distance is stored as x and z tool length offsets in the Tooling Data File. This allows the programmer to program as if the tool tip is at the same location for all tools. The Tooling Data File also includes the tool nose radius dimension and location code associated with each tool.

The Tooling Data File allows 32 sets of tooling data to be stored in the file. Each set of tooling data consists of the following:

- x and z tool length data
- Tool location code data
- Tool nose radius dimension data

The Tool Length Data of the file can be deleted by MSD (Machine Setup Data). The range and format of all data in the file are MSD selectable. (See Appendix A for MSD codes.)

x- and z- Tool Length Data

The format of x and z Tool Length Data can be MSD selectable as

$\pm$ 4 Digits

$\pm$ 5 Digits

$\pm$ 6 Digits

If the Tool Length Data is not desired, it can be removed by MSD.

The Tool Length Data are only beneficial when Absolute programming is used. They offer no advantages with Incremental programming.

If the Tool Length Data is selected, the programmer has to establish and enter the x- and z- tool length after he has determined which point (normally the reference point on the tool holder) he wants to use to program. The following sketch shows how this is accomplished.

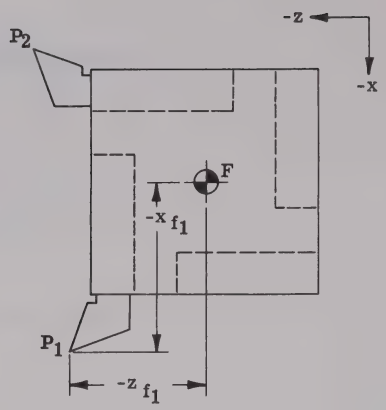


Figure 4

F = Reference point on the turret (location of programmed cutting tip)

P_1 = Imaginary tool tip, tool #1

P_2 = Imaginary tool tip, tool #2

x_{f_1} = Tool length in x axis, tool #1

z_{f_1} = Tool length in z axis, tool #1

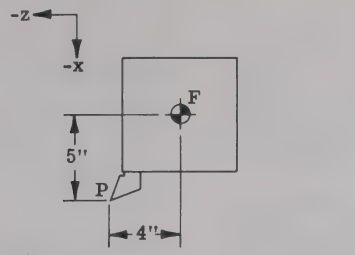
The x and z Tool Lengths are measured from the imaginary tool tip "P" to the tool reference point F.

Since the Control algebraically adds the x and z tool lengths values to the respective position register (without any resulting machine motion), it is important to set the sign (+ or -) of the Tool Length Data in accordance with the machine's coordinate system.

The sign of the x and z tool length is determined by the direction from the reference point "F" on the tool holder or turret, towards the imaginary tool tip "P".

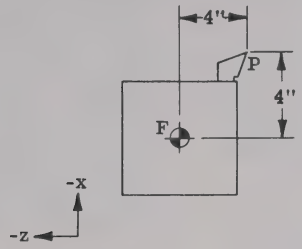
Examples:

(a)



x = 5.0000
z = 4.0000

(b)



x = -4.0000
z = +4.0000

Tool Tip Radius and Location Code

The range of the tool tip radius can be selected by MSD to

4 digits	± 0-0.9999 inch
	± 0-9.999 mm
5 digits	0-9.9999 inches
	0-99.999 mm

The 4-digit system with sign (+/-) should be selected, if computer prepared part programs are used, since a tool nose radius has been incorporated into the calculated path. The radius value to be used is a plus or minus value from the radius used when the part program was generated. (See Appendix A for MSD codes.)

The Tool Location Code is an unsigned one-digit number from 0 through 8. A location code of zero signifies that the tool tip radius center point rather than the imaginary tool tip has been programmed.

Input of Tooling Data File

The Tooling Data File allows 32 sets of tooling data stored in the file. Each set of data contains the location code, tool nose radius and also may contain x and z tool length offsets.

Each set of data in the file is numbered from 1 through 32. Individual sets in the file can be selected by the corresponding tool number (1-32). The data of the Tooling Data file can be entered either manually or from tape.

Manual Entry of Tooling Data

Set the display selector switch on the control panel to the TOOLING DATA position. Set the letter address to "T" and follow by 2 digits (tooling data number) or push the Next pushbutton to select the desired tooling data set. Depending on what tooling data has to be entered, set the letter address to the desired letter and key in the value. After all digits of the value are entered, push the Store pushbutton. Repeat the procedure if other data entry is desired.

Letter addresses for the tooling data file:

T = The tooling data block number

L = The tool tip location code

R = The tool tip radius

X = The tool length parallel to the x axis

Z = The tool length parallel to the z axis

Tape Entry of Tooling Data

Tooling data may be entered via paper tape. This may be a separate tape or may be at the beginning of a part program tape. The data on the tooling data tape can be transferred into the tooling data file only after Cycle Start is activated. The tooling data is not transferred to the data file during a tape wind operation, sequence number search, or wind to reference code.

The tooling data block on the tape must contain a g27 code after the block number n. A 2-digit t code specifies the tooling data set number; the s and z are used for the tool length data; r for the value of the tool nose radius, and L for the tool location code. The tooling data block may omit the n code if desired.

Example:

```
n0001  g27  t99

n0002  g27  x100000  z-6000   r2000  L1  t01

n0003  g27  x-50000  z+70000  r800   L5  t16
```

Block n0001 g27 t99 resets the entire tooling data file to a blank condition (described in a later section).

Block n0002 t selects the number 1 tool data set in the file and sets x and z lengths to +10.0000 inches and -0.6000 inches, respectively. The location code is set to 1 with tool nose radius of 0.2000 inch.

Block n0003 processes data for tooling data set 16.

If the tooling data blocks are part of the program, each time this program is executed, the tooling data is transferred to the data file. When this program is executed from part program storage and a tooling data block contains incorrect data, the Edit option (described in the 1050T handbook) may be used to correct it.

A stop code may be inserted between the tooling data tape and the beginning of the part program. Thus, when an m30 is executed or the tape is rewound using the Tape Rewind function, the rewind does not include the tooling data blocks. In this way, incorrect data may be changed after the initial reading by using the Control panel keyboard (see "Reset and Modification of Tooling Data File," above) without automatically reloading the original tooling data after each m30.

Since the tooling data entry tape is treated the same as the part program, the tooling data tape can also be executed from the program storage.

Reset and Modification of Tooling Data File

Data in the tooling data file is set to a blank condition when the 1050T Executive software is loaded or upon execution of a t99 command.

A blank condition in the tooling data file is an indication that no entry or no value is stored in a particular data field in the file. It is different from an actual zero value. If a zero value is desired, the user must enter a zero value in the file.

A t99 command is a special command to clean the entire tooling data file, i.e., set the file to a blank condition. The t99 command can be entered either via paper tape as described in "Tape Entry," (this page) or via manual data keyboard by selecting the t letter address, entering 99 and depressing the Store pushbutton. When t99 is entered via tape, no other data except the n code and g27 are permitted in the block with t99.

When the tooling data tape is stored in the program storage as part of a part program or a separate tape, modifications to the tooling data tape can be performed using the Edit function of the 1050T Control (described in the 1050T instruction book).

If modifications of the existing data in the tooling data file are desired, use the method described in manual tooling data entry (described on page 7).

Whenever a data set in the tooling data file is active, no data entry or modification is allowed in that active data set which is denoted by an "*" in front of the data on the display. Only the selected inactive data set denoted by ">" can be modified.

Activation of Tooling Data File

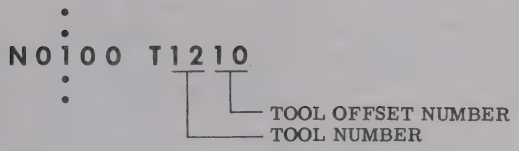
A data set in the tooling data file can be activated by the t code in the part program. The data in the active data set will be used in the tool length adjustment and the tool nose radius compensation.

The activation of the tooling data set in the file can be assigned to

either	-	Tool number
or	-	Tool offset number
of the t code	-	This is MSD selectable.

When the tool offset number of the t code is selected to activate the tooling data, it will activate both the tooling data set and the corresponding ordinary tool offset pair. (See Appendix A for MSD selection code.)

Example:



In this example, the tool number 12 and tool offset pair number 10 are programmed. If the tooling data activation has been assigned (by MSD) to the tool number, tooling data set number 12 would be activated with offset pair 10, but if the activation has been assigned to the tool offset (by MSD), tooling data set number 10 and tool offset pair 10 would both be activated.

When a tooling data set is made active, the x and z tool length data in the active set is algebraically added to the respective position registers. When a tooling data set is deactivated, the x and z tool length data are subtracted from the position register. No machine motion results from the tool length operation.

After a new tool length activation (new tooling data set), the Control must be in the Absolute mode for at least one move in order to use the tool length offset and bring the tool into the correct position.

Whenever a tooling data set which contains a blank condition is activated, an error message OFFSET ERROR-ZERO MACHINE is displayed and cycle start removed.

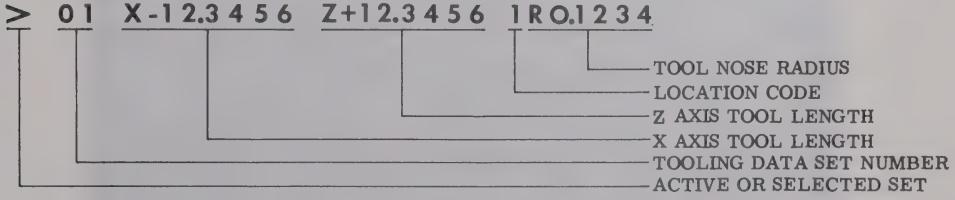
Special note should be made of the interaction between the tooling data and g92 blocks, set zero, and grid zero. None of these actions remove the tooling data from the position registers. For example, if x axis has a tooling data of -02.0000 and a g92 with x +06.0000 is executed, a block with t0000 would cause the x position register to be +04.0000. Set and grid zero cause the position registers to be zeroed; however, the tooling data would be remembered. Thus any change in t number causes the active data to be subtracted from the position register and the new data added. Reference zero causes the tooling data in the axis referenced to be removed.

Display of Tooling Data

Set the Display selector switch to TOOLING DATA to display the tooling data file. Eight sets of tooling data can be displayed at one time. Each data set contains the x and z tool length data, the tool nose radius r, and a one-digit tool location code which is displayed just in front of the letter r. The active tooling data set is denoted with the symbol "*". An ">" in front of a tooling data set indicates that this specific set has been selected either by pushing the Next pushbutton or by entering its t number via the keyboard.

If the tool length data is not used and has been deleted by MSD, the tooling data file display will only show the tool nose radius r and the location code.

The display format of a data set in the tooling data file display is shown as follows:

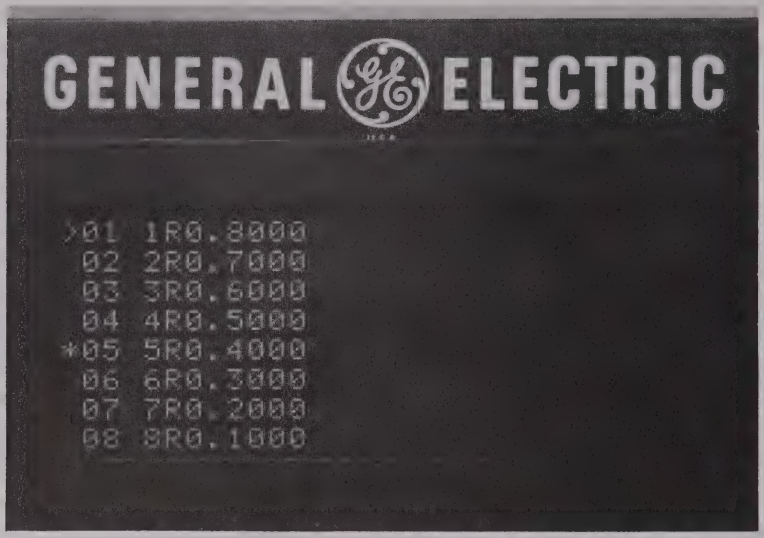


A blank condition in the tooling data file is indicated on the display as blanks. Thus,

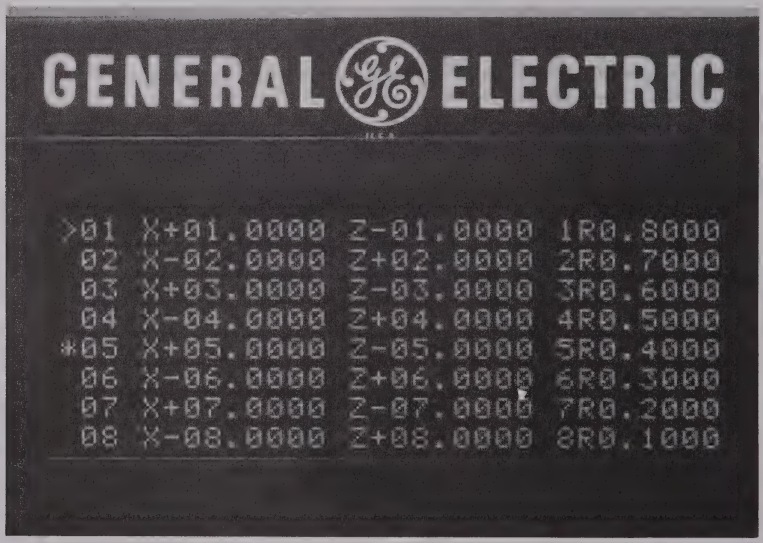
x z+00.0000 would signify '

that x contains a blank condition and z contains an entered zero (via tape or keyboard).

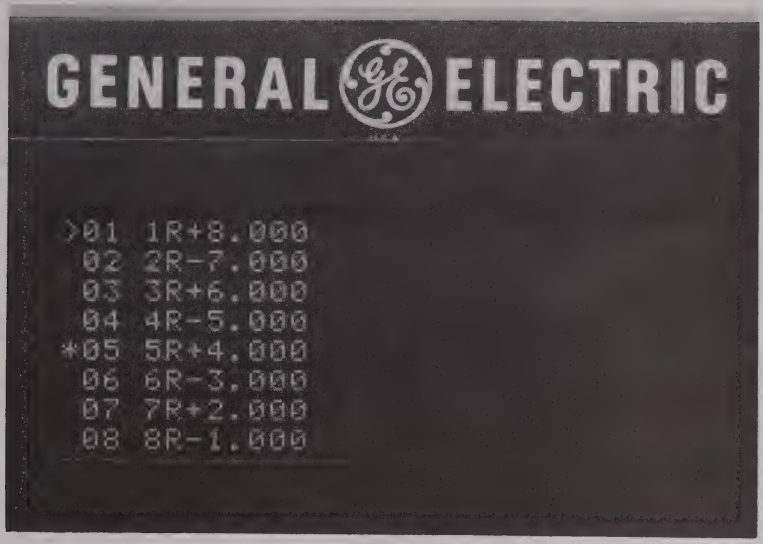
Figures 5 through 8 show some typical examples of the tooling data display.



Ref. 789-25-1031 Figure 5.

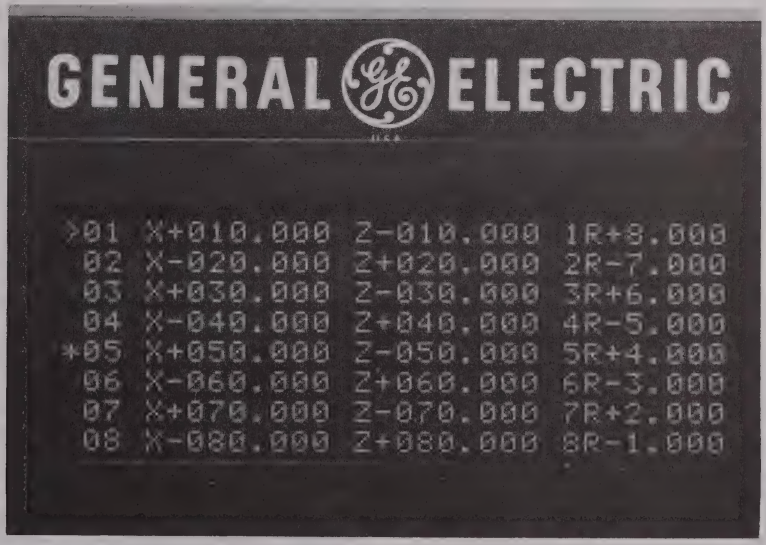


Ref. 789-25-1032 Figure 6.



Ref. 789-25-1030

Figure 7.



Ref. 789-25-1033

Figure 8.

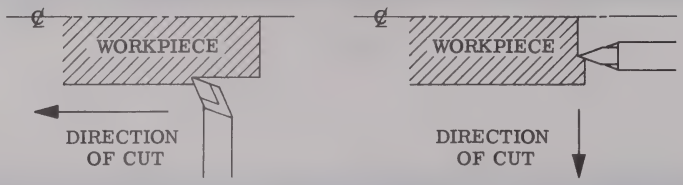
TOOL NOSE RADIUS COMPENSATION

If the part programmer programs a part with the imaginary tool tip without any compensation allowance for the tool nose radius, only the cuts parallel to the two axes can be performed without any deformation of the workpiece contour. To avoid these contour deformations, the tool nose radius compensation can be used rather than the programmer making the calculations to allow for the tool nose radius.

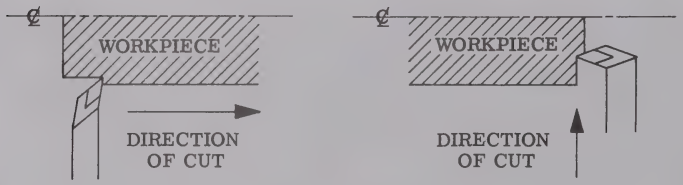
The tool nose radius compensation feature allows the programmer to actually use the imaginary tool tip to program his part. The programming procedures can be simplified by just programming with the actual work surface dimension of the workpiece. The feature also allows different tool nose radius to be used for the same program without any recalculation or programming.

Example:

(a) g41



(b) g42



Activation of Tool Nose Radius Compensation

The tool nose radius compensation is activated by programming a g41 or g42 code. The radius value of the active tooling data set in the tooling file is used for the compensation. If no tooling data set was activated before a g41 or g42 activation, a radius of zero is used.

g41 - Signifies that the tool tip is to the left of the workpiece when viewed in the direction of the cut.

g42 - Signifies that the tool tip is to the right of of the workpiece when viewed in the direction of the cut.

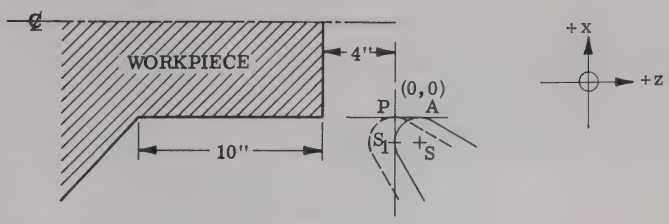
g40 - Cancels Tool Nose Radius Compensation

If the radius value of a programmed tool is a blank condition, error message OFFSET ERROR - ZERO MACHINE is displayed and cycle start removed as soon as the activated t code of the tooling data (either tool number or tool offset, selected by MSD) is read from the part program or entered via keyboard. The same error sequence takes place if no valid or blank location code is recognized.

To enter the tool nose radius compensation, the part programmer positions the imaginary tool tip at the beginning of the first cut, programs the left/right g command (g41, g42) and the tool nose radius compensation is entered without any physical movement of the tool. After reading the first axis move block after the radius compensation activation, the Control generates a command to place the contact point of the tool nose radius on the point "P" of the imaginary tool tip prior to the programmed move and carries on with the programmed move block. The generated move is executed at the current programmed feed rate.

Example:

(a) Assumption: Tool Location Code = 5

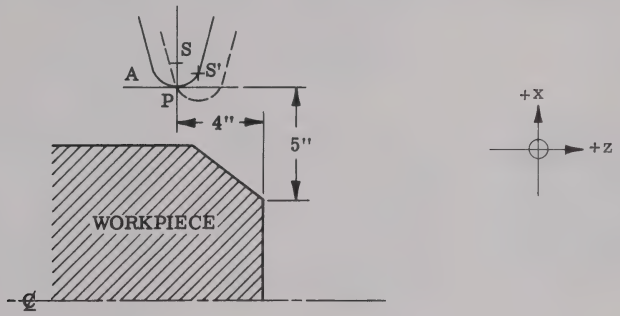


n1 g21 x0 z0 f00 t0101 — The imaginary tool tip is positioned to point "P".

n2 g41 — Tool tip compensation is entered without movement.

n3 g01 z140000 f150 — The contact point of the tool nose radius A is placed to the point "P" (the tool move from S to S_1) and then block n3 is executed.

(b) Assumption: Tool Location Code = 2



n05 g41 — Tool nose radius compensation activation.

n06 g01 x-05 z04 f3 — The Control first generates the command to place, the tool nose contact point A to P and then n06 block is executed.

In principle, the first move after the tool nose radius compensation is activated puts the tool nose arc tangent to the imaginary tool tip "P", then the first programmed move will be executed.

In example (b)

S to S' = Move to put the tool nose arc tangent to point "P".

After the Tool Nose Radius Compensation is activated, the following programmed moves will be offset by the Control with the correct tool nose radius compensation until a cancellation command (g40) is recognized.

Cancellation of Tool Nose Radius Compensation

In general, a cancellation command must be programmed after the tool nose radius compensation is completed. The cancellation command consists of a g40 code in the program.

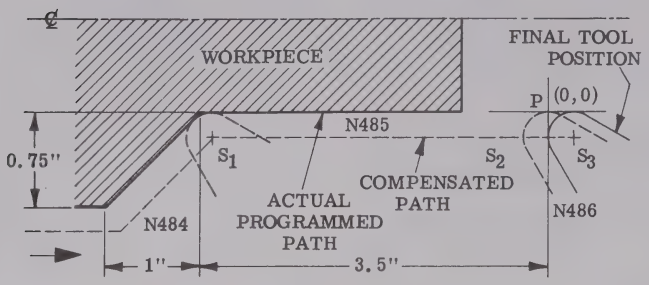
Cancellation by g40 Command

Programming a g40 preparatory command removes the tool nose radius compensation. If the g40 command block does not contain a departure command, the Control finishes the previous move to the computed endpoint (with radius compensation); then a command is generated to move the tool to the uncompensated programmed position. Thus, the imaginary tool tip will be on its actual programmed position. If a departure command is included in the g40 block, the generated command block (described above) will be executed first before the departure command

Example:

Assumption: g42 active, Tool Location Code = 5

Incremental Programming



Part Program:

```
•
•
•
n484  g01  x7500  z10000 f150   Slope cut, tool stop at S1
n485  x35000                    Z axis cut, tool moves from S1 to S2
n486  g40                       Cancel tool nose radius compensation
•                               The tool moves from S2 to S3 in order to
•                               place the tool at the uncompensated pro-
•                               grammed position; thus, the imaginary
                                tool tip is on the actual programmed position
                                "P".
```

A g40 command only cancels the tool nose radius compensation; it has no effect on the active tooling data, i.e., the active tooling data set remains active. The active tooling data set can only be changed or cancelled by a new t code or t0000 command.

Cancellation by a Zeroing Command

Zeroing the Control by Set Zero, Reference Zero or Grid Zero causes the radius compensation to be removed. However, there is no specially generated motion or data to be combined with command to remove the compensation. If a g41/g42 preparatory command is active, it is cancelled. (See Page 9 for interaction with the tool length data.)

Cancellation by a Clear Operation

Whenever the Clear pushbutton is depressed, the active tool length offset and tool nose radius compensation are cancelled. The active tool length offset is subtracted from its respective position register, and if g41 or g42 is active during a clear operation, the tool nose radius compensation is cancelled with no physical motion. Therefore, the actual position will be lost and error message OFFSET ERROR - ZERO MACHINE is displayed to alert the operator.

Cancellation by Emergency Stop

If an emergency stop condition arises, the same process will occur as when pushing the Clear pushbutton. (See above paragraph.)

Cancellation by m30/m02

A g40 cancellation command must be programmed at least one block before an m30 or m02 block; otherwise, the clear sequence takes place and position is lost. (See above paragraph.)

Changing Active Tool Nose Radius

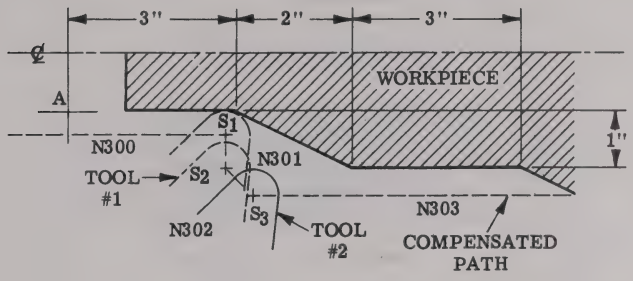
The values of an active tooling data set cannot be changed.

If the current active radius value has to be changed due to tool change, a new tooling data set which contains the new tool nose radius must be activated by a new t code (either the t number or tool offset pair number). If this occurs, the old active radius value is cancelled. The Control completes its current move so that the tool arc is tangent to the programmed

endpoint. Then the activation of the new tool nose radius compensation sequence occurs (see page 17). Since a new tooling data set is activated, the tool length offset is also affected.

Example:

Assumption:
x and z tool length are deleted by MSD
Tooling Data Set No. 1: L = 7 r = 0.1 inch
Tooling Data Set No. 2: L = 7 r = 0.2 inch
g42 active
Incremental programming
Tool number is selected to activate tooling data



Part Program:

•
•
•

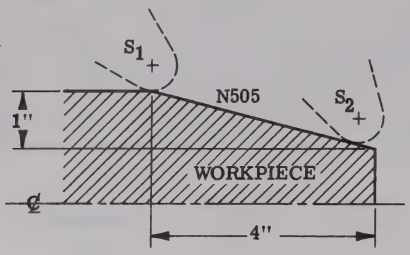
n300 g01 z03 f150	Z axis cut with radius compensation. Tool stop at S_1
n301 x-01	X axis move to tool change position. Tool stop at S_2 with the tool arc tangent to the programmed endpoint due to the new t code encountered in next block.
n302 g04 x6 t0202	Tool change with dwell. New tooling data set is activated without motion.
n303 z05	Tool moves from S_2 to S_3 in order to place the tool arc tangent to the programmed starting point. Then block n303 is executed with radius compensation.

Traverse Moves

Whenever a traverse code is programmed in a block with or without departure command, the previous programmed feed move is completed with radius compensation active. The tool feeds to the point where the tool arc is tangent to the programmed path and tangent to a slope that forms a 90-degree inside corner with the programmed path.

Example:

Assumption: Tool location code L = 1
g41 active



•
•
•

n505 g01 x-1000 z40000 Tool move from S_1 to S_2 with radius compensation. The tool feeds to the point S_2 where the tool arc is tangent to the programmed path and tangent to a slope that forms a 90-degree inside corner with the programmed path due to the traverse code in the Next block.

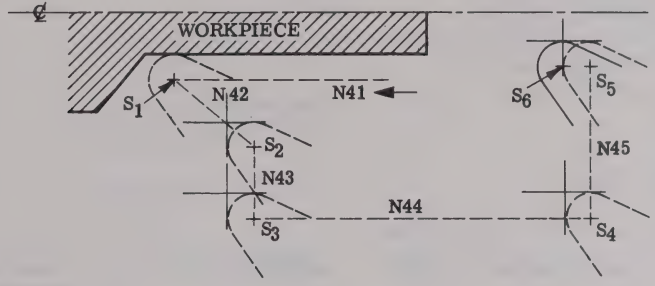
n506 x10000 f99 Traverse Code

While in the Traverse mode, no tool nose radius compensation takes place. The Control traverses the actual positioning commands; thus, the tool tip compensation is "frozen."

The "freezing" of the tool tip compensation is removed at the end of the last traverse block which is followed by a feedrate block. After the completion of the last traverse move, the tool radius compensation activation sequence takes place again, i.e., the Control puts the tool arc tangent to the programmed move at starting point of the feed move.

Example:

Assumption: Tool location code = 5
g41 active



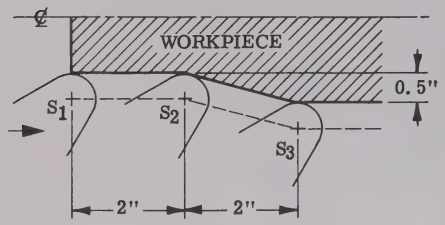
▪	
▪	
▪	
n41 g01 z30000 f1500	Z axis cut with radius compensation. Tool stop at S_1 due to the traverse move in block n42.
n42 g91 x1000 z1000 f00	Pull out movement with 45° angle. Traverse move and radius compensation is frozen.
n43 x50000	Retract movements in x
n44 z100000	and z axes with traverse.
n45 g90 x40000	Radius compensation remains frozen. Tool stops at point S_5.
n46 z30000 f1500	Cutting move; radius compensation is reactivated. Tool moves from S_5 to S_6 to place the tool arc tangent to the programmed move at the starting point of the move.

Programming

The Tool Nose Radius Compensation feature has the capability of looking ahead in order to calculate the correct endpoint of each move (it is known as one-block, look-ahead compensation). The endpoint of each move (except traverse moves and the Single or MDI mode) with g41 or g42 active is computed such that the arc of the tool is tangent to the programmed paths of both the current move and the following move.

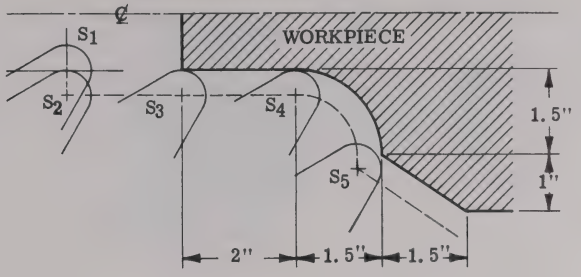
Example:

(a) Assumption: Location Code = 7
Incremental Programming



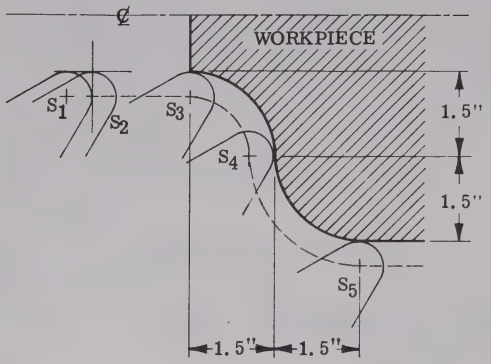
n010 t0101	Tooling data set activation	n040 z02	Z axis cut, tool stops at S_2 which is tangent to both n040 and n050 block moves.
n020 g42	Tool nose radius compensation activation.		
n030 g01 z04 f150	Placing tool in cutting position, tool stops at point S_1.	n050 x005 z02	Slope out, tool stops at S_3.
		•	
		•	
		•	

(b) Assumption: Location Code = 0 (programmed with the tool nose radius center)
Incremental Programming
Tool is placed initially at S_1



n001 g42 t0304	Activate both tooling data set and tool nose radius compensation
n002 g01 z02 f15	Tool is placed in the cutting position. The tool is first moved from S_1 to S_2 and stops at S_3.
n003 z02	Z axis cut, tool moves from S_2 to S_3 which is tangent to both the programmed path in blocks n003 and n004.
n004 g03 x015 z015 I015	Counterclockwise arc cut, tool moves from S_4 to S_5.
•	
•	
•	
•	

(c) Assumption: Location Code = 7
Incremental Programming
Tool is placed at S_1 initially.



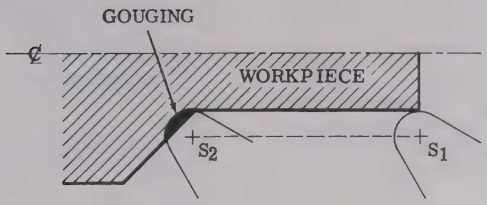
n01 t0505	Tooling Data Set Activation
n02 g42	Tool Nose Radius Compensation activation.
n03 g01 z03 f15	Place tool in cutting position. Tool first moves from S_1 to S_2 and stops at S_3.
n04 g03 x015 z015 I015	Counterclockwise arc cut, tool moves from S_3 to S_4 which is tangent to both arc moves in blocks n04 and n05.
n05 g02 x015 z015 k015	Clockwise arc cut, tool moves from S_4 to S_5.

If, because of geometric configuration, the tool arc cannot be made tangent to both paths, an error message OFFSET ERROR - ZERO MACHINE will be displayed and cycle start removed. This can occur, i.e., in an arc/arc or line/arc configurations. (Details in later section.)

If the next part program block does not contain an axis departure command, the second block will be used to calculate the compensation. If the second block, however, also does not contain a move, then the endpoint for the current block is based on a point with the tool arc tangent to the programmed path at the end point of the move.

Example:

Assumption: Location Code = 5
g41 Active
Absolute Programming



Part Program:

•
•
•

n40 g01 z100000 — Z axis cut, tool moves from S_1 to S_2. The point S_2 is determined with the tool arc tangent to the programmed move at the end point due to the no motion blocks n41 and n42.

n41 g04 x4000 — No motion dwell block.

n42 m09 — No motion block.

n43 g01 x40000 z300000

•
•
•

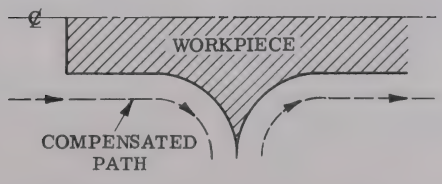
In this example, the tool stops at S_2 instead of the compensated endpoint as described in the previous examples. If this case occurs, the workpiece may be changed or deformed (i.e., gouging at the inside corner). It is the responsibility of the programmer to prevent this from happening.

Programming Limitation*

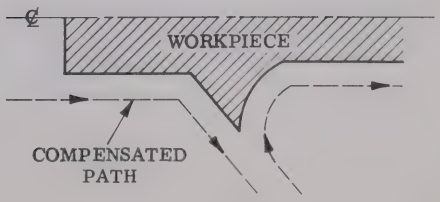
In general, there is no limitation in programming with the tool radius compensation. If, because of geometric configuration, the tool nose arc cannot physically be made tangent to both paths, an error message is displayed. Two possible geometric configurations that cannot be programmed are shown as follows:

Example:

(a) Arc to Arc



(b) Line to Arc



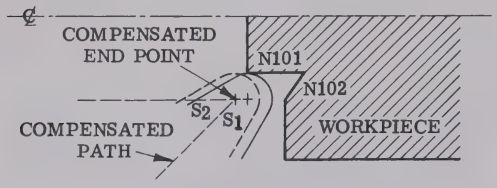
*See Appendix B for Programming Precautions.

In practice, the above configuration will not occur. Usually, the programmer will insert a very small arc or linear cut to prevent the sharp edge formed by the configuration.

As a general rule, to guarantee that a geometric configuration can be compatible with tool nose radius compensation, the intersection point of the tool nose radius center path parallel to the two programmed moves must be established.

If the computed compensation endpoint is opposite in direction to the programmed endpoint because of the geometric configuration, no motion will be made, an error message OFFSET ERROR - ZERO MACHINE will be displayed, and cycle start removed.

Example:



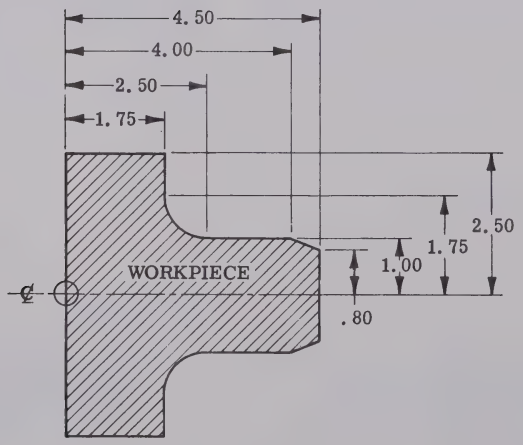
In this example, the tool starts cutting block n101 at S_1. Since the computed compensation endpoint S_2 of the blocks n101 and n102 causes the tool to move in opposite direction of the programmed move in n101, the tool will remain at S_1 and error message will be displayed.

If 2 moves are programmed in succession such that the second move is the opposite direction of the first, motion does not occur, an error message is displayed, and cycle start removed. Since the Control freezes the radius compensation when it is in the Traverse mode, the 180 degree reversed direction moves are allowed if one or both moves are programmed in the Traverse mode. It is the responsibility of the part programmer to insure that his part can be cut by the chosen tool, i.e., the tool nose radius size and orientation must be compatible with the geometric configuration of the part.

Programming Example

The following example shows how to program a typical lathe part with and without Work Surface Programming (with Tool Nose Radius Compensation) feature.

Part To Be Made



Assumption: The part has been rough cut and is ready for the finish cut.

The tool is located at x +6.5 and z +12.75. The approach is at traverse rate (traverse code = f9) to .25 inch from the nose of the part. The tool nose radius is 1/16 (.0625). Correct tool orientation has been chosen.

Part Program Example Without Work Surface Programming Feature

	Comments
n001 g90	Absolute programming
n002 g01 x000625 z048125 f9	Move to center line less the cutting edge of the tool on the center line.
n003 z045625 f010	Move at feedrate to the face of the part less one radius.
n004 x008423	Move to the point where the radius is ready to cut the slope.
	$\triangle x = .0625 * \tan (45 - \frac{\Theta}{2})$
	$\Theta = 21° 48'$
	$\triangle x = .625 * .67705$
	$\triangle x = .6423$
n005 x010625 z040120	Move to the point where the radius is ready to cut the diameter.
	$\triangle x$ = tool radius (.0625)
	$\triangle x$ = tool radius * $\tan \frac{\Theta}{2}$
n006 z0250	Cut diameter to the arc.
n007 g02 x0175 z018125 I006875	The arc center must be shortened by the tool radius as well as the z axis endpoint.
n008 g01 x025625	Facing cut whose endpoint is ready for the diameter cut. Tool radius added to x dimension.
n009 z-000625	Final cut. Must go beyond the zero point by one radius to cut the entire surface.
n010 x065 z1275 f9	Traverse to home position.

Part Program Example With Work Surface Programming Feature

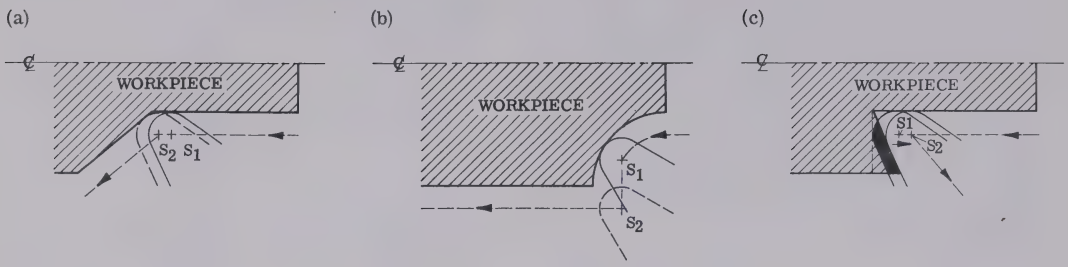
n001 g90 t0101	Absolute Programming. Tooling Data Set No. 1 activation. Radius compensation with tool to left of workpiece.
n003 g01 x0 z0475 f9	Traverse to starting point.
n004 z0450 f010	Feed to face.
n005 x0080	Facing cut.
n006 x01 z04	Slope cut.
n007 z0250	Diameter cut.
n008 g02 x0175 z017 I0075	Arc cut.
n009 g01 x025	Face cut.
n010 z-000625	Diameter cut one radius long to cut entire surface.
n011 x065 z1275 f9	Traverse to home.
n012 g40	Cancel radius compensation.

SINGLE AND MANUAL DATA INPUT MODE

In the Single and MDI modes, the next move is not available for the endpoint computation when Tool Nose Radius Compensation is active. Therefore, the current move will place the tool such that the tool arc is tangent to the programmed path and tangent to a slope that forms a 90 degree inside corner with the programmed path. Prior to the next block with axis motion, a move will be made if necessary to place the tool arc tangent to both the program path of the old and the new move. The new move would then be made with its endpoint calculated as described above.

If the programmed move is less than the radius of the tool nose, a special sequence occurs. The move from the endpoint to the start point of the next move as described is executed. The move for the programmed block cannot be made as this would cause the tool to move in the opposite direction programmed. Therefore, no move is made for the programmed move. When the next programmed move is executed, the move from the endpoint to the start point is the unexecuted block whose distance is less than the radius of the tool nose.

Example:

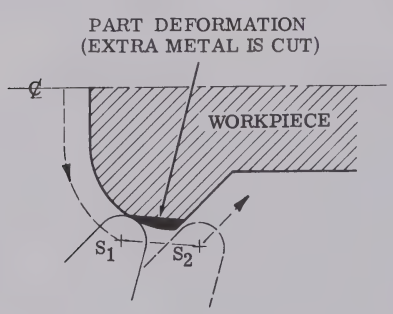


S_1 = Point where the tool stops in the Single or MDI mode.

S_2 = Point where the tool is placed prior to the next move.

In the Single or MDI mode, part deformation can occur whenever an arc move is encountered. It is because the tool stops at the endpoint as described in the examples above, and moves in a straight line to the computed compensation endpoint instead of a continuous arc move. This causes extra metal to be cut or uncut. This deformation error will not occur in the Auto mode of operation.

Example:



In this example, the tool stops at S_1 after the arc move in the Single mode. Then the next slope cut is activated and the tool moves from S_1 to the computed endpoint S_2 horizontally, and extra metal is cut.

The 180-degree reverse direction moves limitation (see page 22) is also applied in the Single or MDI modes.

THREADING

Since the tool nose radius is not applied to most of the thread cut tools, it is recommended that radius compensation be cancelled before performing any threading moves. However, if a threading move is encountered with radius compensation active, the moves are treated the same as traverse moves (see page 16).

m00/m01

M00 and m01 are program stop codes. These codes may be executed with tool nose radius compensation active. When an m00 is encountered, no additional blocks of data are read. Therefore the radius compensation treats a block that contains an m00 code as being followed by 2 blocks of no motion. Thus the last programmed move will end with the tool nose arc tangent to the programmed move at its endpoint.

Because an m01 code ia a conditional stop, part program data is read past the block which contains the m01 code. Thus if executed, the last programmed move prior to the m01 code stops with its endpoint based on the rules started above.

CONTROL STATUS READOUT

Because the tool nose radius compensation is a changing value, the Distance to Go and Position register display are handled as follows: the Distance to Go shows the value for the actual distance (including compensation) that the axis has to move.

The position register display is formed by an internal register that contains the value for the endpoint of the current move and subtracts the Distance to Go. This method still applies when radius compensation is active. Thus, during a move, the position register may be incorrect by the amount of compensation currently active. The value may be a changing value during a move. At the end of a programmed move, the position register reflects the true programmed position.

APPENDIX A
MSD FOR WORK SURFACE PROGRAMMING

ITEM	MSD CODE	WORDS TO BE SPECIFIED	DATA	DEFAULT DATA
Work Surface Programming Option Active	L1117	m _ _	m00 = NO m01 = YES	m01
Tool Length Data Active	L1118	m _ _	m00 = NO m01 = YES	m01
Tool No. Used for Tooling Data	L1121	m _ _	m00 = NO m01 = YES	m00
x Plus Direction Away From Operation	L1126	m _ _	m00 = NO m01 = YES	m00
Tooling Data Format (Used with Work Surface Programming)				
English	L1903	x _ _	04, 14, 24	24
Metric	L1904	x _ _	13, 23, 33	33
Note: English and Metric Formats must contain the same number of digits.				
Tool Tip Radius Format (Used with Work Surface Programming)				
English	L1905	x _ _	04, 14	14
Metric	L1906	x _ _	13, 23	23
Note: English and Metric Formats must contain the same number of digits. A radius format with 5 digits will always be a plus value.				

L1117 - Work Surface Programming Option.

This MSD code allows the Work Surface Programming option to be activated or deactivated when the option is part of the executive software.

L1118 - Tool Length Data

This MSD code activates or deactivates the tool length data. When activated the display shows the x and z values, and these values are used when a t code is programmed. (See page 6.)

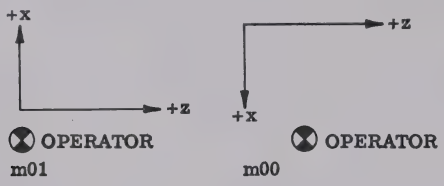
L1121 - Tool Number Used for Tooling Data

This MSD code allows the tool data to be selected with the offset number or the tool number in the t code. (See page 8.)

L1126 - x Plus Direction Away From Operator

This MSD code establishes for the Control the x/z plane of the lathe. With the operator standing such that a z axis plus motion would move the tool to the right, if an x axis plus move causes the tool to move away from the operator, use the m01 code.

If an x axis plus move causes the tool to move toward the operator, use the m00 code.



L1903/L1907 - Tooling Data Format

These 2 codes establish the formats of the x and z tool length data. The first digit specifies the number of digits to the left of the decimal point and the second digit the number of digits to the right of the decimal point. (See page 6.)

L1905/L1906 - Tool Tip Radius Format

These 2 codes establish the format of the r or radius value of the tool tip. The first digit specifies the number of digits to the left of the decimal point and the second digit the number of digits to the right of the decimal point. (See page 7.)

APPENDIX B
PROGRAMMING PRECAUTIONS

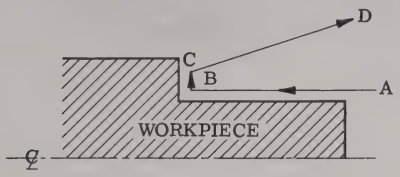
SINGLE AND AUTO MODE PRECAUTIONS

1. There are 2 geometric configurations that cannot generate a compensated path. See page 21 for a description of these configurations.

2. Moves equal to or less than twice the radius of the tool nose may cause the error message "OFFSET ERROR-ZERO MACHINE" to be displayed and prevent the move from being executed in Auto or Single mode. The moves preceding and following short moves must be examined to determine if the short move can be executed.

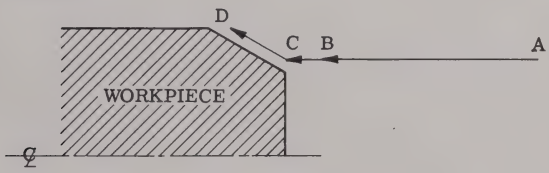
Following are 3 examples of the above precaution.

Example:



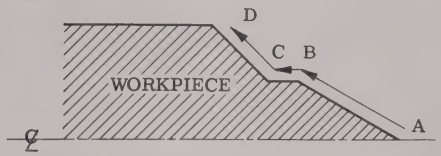
The moves from A to B and B to C are at feed rate. The move from C to D is at traverse. If the move from B to C is less than the diameter of the tool nose, the move cannot be made. The compensated path would cause the tool to move opposite the programmed path for B to C. Therefore, to overcome this restriction move B to C should be programmed greater than the diameter of the tool nose.

Example:



If B to C is less than the radius of the tool, the moves cannot be made. The compensated end point for move A to B is with the tool nose tangent to A to C at point B. This places the tool nose tool close to the workpiece and thus the motion to align the tool for the B to C move would be in the opposite direction from the programmed move.

Example:



All moves are at feed rate. The B to C move is less than the radius of the tool nose. It may or may not be executed depending on the following factors:

A. Length of move B to C compared to tool nose radius if less than radius of the tool.

B. The angle of the slope A to B, to B to C.

C. The angle of the slope C to D, to B to C.

To overcome the precautions in example 2 and 3, move B to C should be programmed greater than the radius of the tool nose.

Another example is found on page 22.

SINGLE MODE PRECAUTIONS

1. No motion blocks are not to proceed or follow motions equal to or less than the diameter of the tool nose. If no motion blocks do occur, the path generated in the Single mode will be incorrect. Operation in Auto mode is not affected.

INDUSTRIAL CONTROL DEPARTMENT, GENERAL ELECTRIC COMPANY, WAYNESBORO, VIRGINIA

COMMUNICATION INTERFACE OPTION

The Communication Interface option allows a numerical control (N.C.) to transmit and receive messages, part programs, and machine status reports from a computer. The Communication Interface has built-in error detection and retransmission methods which require little or no operator intervention.

The Communication Interface uses an adaptation of the Binary Synchronous Communication procedures. The Binary Synchronous Communication provides a set of rules (Protocol) for the asynchronous transmission of binary-coded data.

Protocol is concerned with the transmission of physically correct messages between stations in the system. This includes error detection, notification of message receipt, and retransmission of message if required. Protocol is used to transmit part programs.

The Communication Interface option can also be used without Protocol. This is done by using the Terminal mode. Message and commands are usually transmitted in the Terminal mode.

DATA TRANSMISSION

Type: Asynchronous
Rate: 110, 150, 300, 600, 1200, 2400, BAUD
Interface: Voltage or 20 ma current loop
Characters: ASCII

This publication is divided into 5 main areas:

	Page
1. Establish/Terminate Protocol	2
2. Transmit and Receive Messages	3
3. Transmit and Receive Part Programs	5
4. Transmit Machine Status Reports	8
5. Appendix A	9
6. Appendix B	10

ESTABLISH/TERMINATE TRANSMISSION PROCEDURES

ESTABLISHING TRANSMISSION

When high reliability is required for data transfer, Binary Synchronous Communication procedures (Protocol) should be used. Protocol may be initiated by the computer and, in some cases, by the N.C.

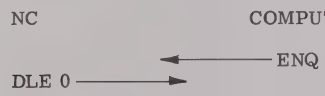
The computer initiates communication Protocol by sending ENQ to the N.C. When the N.C. receives the ENQ, it replies with DLE 0. At this point, Protocol is establishment. The computer has control of the communication line, and the N.C. becomes the slave station. If the N.C. is unable to accept the ENQ, it replies with NAK. If the computer still wants control of the communication line, it has to send another ENQ.

The computer has the option of sending along with the ENQ an 8-character ASCII N.C. identification number (I.D.). If the computer does not send the correct I.D. number, the N.C. replies with NAK.

The N.C. can only initiate Protocol when requested to do so by the computer. The request to send data via Protocol is in the form of a command message sent by the computer. The command messages are:

SNIY - Reply after receiving message
RNL - Request for machine status
RNS - Request for parts program

Example: The computer initiates Protocol and is in charge of the communication line:



Example: The computer initiates Protocol and, at the same time, sends the I.D. number of the N.C. with which it is communicating.

TERMINATE TRANSMISSION

The N.C. or computer can terminate Protocol by sending an EOT. After EOT is transmitted, an establishment procedure must be reinitiated again.

Termination may be initiated by either N.C. or the computer if one of the following conditions are met:

1. Successful transmission of a message.

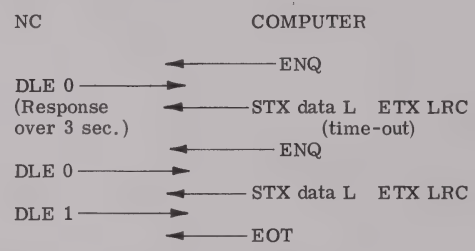
2. Three consecutive ENQs are sent without an acknowledgment due to time-outs.

3. Three consecutive NAKs are received, without an affirmative acknowledgment.

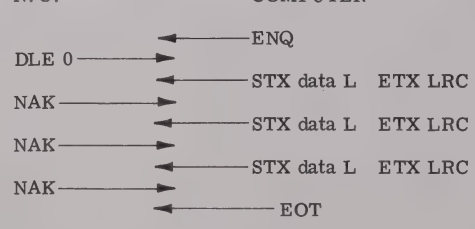
4. The N.C. did not have enough memory to accommodate a part program being down loaded.

Time-out: The computer uses a timer (normally 3 seconds after transmission of the last character) to time-out the N.C. response. When the N.C. does not respond in the time allotted, the computer must transmit an ENQ character, thereby requesting prior acknowledgment.

Example: Time-out



Example: Three consecutive NAKs without an affirmative acknowledgment.



TRANSMIT AND RECEIVE MESSAGES

TRANSMIT AND RECEIVE MESSAGES WITHOUT PROTOCOL

In the Terminal mode, there is no check for message integrity. However, the operator does have the capabilities of editing the message before he sends it out onto the communications line to the computer.

The Terminal mode is also used to log onto the computer system.

1. Transmit - N.C. To Computer

Example: The operator wishes to send a message or log onto the computer. The operator places the Mode selector on MDI and the Display selector on MESSAGE RECALL; he then keys in a message up to 32 characters. If the operator makes an error or wishes to change the message, he can edit the message in one of two ways:

A. He can edit character-by-character by depressing the Minus (-) sign button twice. On the next (third) press of the Minus (-) sign button, the last character entered is blanked from the display. With each press of the Minus (-) sign button, one more character is removed.

B. The entire message can be blanked from the display by depressing the Plus (+) sign twice.

When the operator is satisfied with the message, he pushes the Punch/Send button on the auxiliary control panel. At this time, the display is blanked and the message CARRIAGE RETURN is added to the message as it is being transmitted on the communications line.

2. Receive - N.C. From Computer

The N.C. monitors the communications line at all times and saves the first 32 non-control characters received. Upon receiving a carriage return, the saved 32-character message is stored, and the Message Recall light turns on. When the Display selector is in the MESSAGE RECALL position, the message is displayed.

TRANSMIT AND RECEIVE MESSAGES WITH PROTOCOL

In most cases, the N.C. (see page 2), cannot initiate a message being transmitted via Protocol. However, the N.C. can transmit a message via Protocol if the computer requests it to do so. The communications software within the N.C. has to be steered toward transmitting or receiving a message via Protocol. The steering device is a command message and can only be sent by the computer.

The command message is the first message sent from the computer to the N.C. following an establishment procedure ENQ. See the structure and definition of command messages described in Appendix A.

1. Receiving - Computer To N.C.

The following example describes an N.C. receiving a message via Protocol from the computer. Arrows show directional flow of information only.

Example: The computer wants to send N.C. No. 1945 a message via Protocol. The message reads WHAT TIME IS IT and also wants a reply to the message in Protocol.

STEP	N.C.		COMPUTER
A		←	SOH 1945 ENQ
B	DLE 0	→	
C		←	STX SNIY ETX LRC
D	NAK	→	
E		←	STX ANIY ETX LRC
F	DLE 1	→	
G		←	STX WHAT TIME IS IT ETX LRC
H	DLE 0	→	
I		←	EOT

STEP	DESCRIPTION
A	The computer asks for control of the communication line from N.C. (1945).
B	The N.C. sends an affirmative acknowledgment.
C	The computer sends a command message telling N.C. communication software that a message will be displayed and that the computer wants a reply to the message.
D	The N.C. sends NAK; N.C.'s communication software detected an error in the transmitted message.
E	The computer retransmits a command message.
F	The N.C. sends an affirmative acknowledgment.
G	The computer sends a message WHAT TIME IS IT.
H	The N.C. sends an affirmative acknowledgment.
I	The computer terminates transmission and releases control of the communication line.

The operator at the N. C. sees on his display a message, WHAT TIME IS IT, and at the same time, the message recall light turns on. The operator then keys in his reply, THE TIME IS 8 O'CLOCK, and then pushes the Send button. When the Send button is pushed, the message is removed from the display and stored in the communication buffer. The Send pushbutton lights turn on and remain on until the computer sends a command message requesting data from the N. C. 's display.

2. Transmitting - N. C. To Computer

The following is a continuation of the previous example. Arrows show directional flow of information only.

Example: The operator has just keyed in a reply message, THE TIME IS 8 O'CLOCK, and is waiting for the computer to ask for that message reply.

STEP	N. C.	COMPUTER
A		← SOH 1980 ENQ
B	NAK →	
C		← SOH 1945 ENQ
D	DLE 0 →	
E		← STX RNI ETX LRC
F	DLE 1 →	
G		← EOT
H	SOH 1945 ENQ →	
I		← DLE 0
J	STX THE TIME IS 8 o'clock ETX LRC →	
K		← NAK
L	STX THE TIME IS 8 o'clock ETX LRC →	
M		← DLE 1
N	EOT →	

STEP	DESCRIPTION
A	The computer asks for control of the communication line from the N. C. (1980).
B	The N. C. responds with a negative acknowledgment because the N. C. I. D. number is incorrect.
C	The computer retransmits establish procedures.
D	The N. C. responds with an affirmative acknowledgment.
E	The computer sends a command message requesting data from the display followed by LRC.
F	The N. C. responds with an affirmative acknowledgment.
G	The computer terminates transmission and releases control of the communication line.
H	The N. C. asks for control of the communication line.
I	The computer affirms acknowledgment.
J	The N. C. sends a message followed by LRC.
K	The computer detects an error in the last message sent by the N. C.
L	The N. C. retransmits the message.
M	The computer affirms acknowledgment.
N	The N. C. terminates transmission and releases the communication line. The Punch/Send pushbutton light turns off.

If the computer in example B. 1, Step C had sent a command message (SNDN), the N. C. operator could have transmitted a reply message without having to wait for another command message from the computer (RND).

TRANSMIT AND RECEIVE PART PROGRAMS

RECEIVE PART PROGRAMS - COMPUTER TO N.C.

The computer or N.C. can initiate the down loading of a part program. If the computer initiates the down loading, no N.C. operator intervention is required. If the N.C. does not have memory to accommodate the part program, the N.C. transmits an EOT.

NOTE

There is one restriction when down loading a part program. Cycle Start cannot be active.

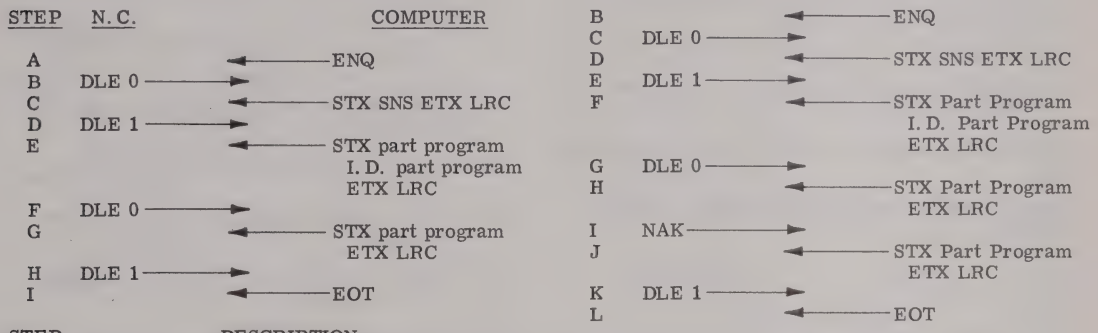
The computer initiates down loading in the following manner.

Example: The computer wants to down load a part program.

STEP	DESCRIPTION
A	The computer requests control of the communication line.
B	The N.C. sends an affirmative acknowledgment.
C	The computer sends a command message. The command message tells communication software in the N.C. that the computer will send an N.C. part program.
D	The N.C. sends an affirmative acknowledgment.
E	The computer sends a part program I.D. along with the part program.
F.	The N.C. sends an affirmative acknowledgment.
G.	The part program continues.
H	The N.C. sends an affirmative acknowledgment.
I	The computer releases the communication line.

The operator initiates the down loading of a part program in the following manner.

Example: The operator wishes part program I.D. number 6535 down loaded to him.



STEP	DESCRIPTION
A	The N.C. requests that a part program be down loaded. By requesting the down loading of a part program, the operator is also logging onto the system.
B	The computer asks for control (master status) of the communication line from the N.C.
C	The N.C. responds with an affirmative acknowledgment.
D	The computer sends a command message which tells communication software in the N.C. that the computer will send the N.C. a part program.
E	The N.C. sends an affirmative acknowledgment.
F	The computer sends the part program I.D., part program followed by LRC.

(STEP)	(DESCRIPTION)
G	The N. C. sends an affirmative acknowledgment.
H	The computer sends the second half of the part program.
I	The N. C. responds with a negative acknowledgment because of an error detected by the N. C. The N. C. wants the message retransmitted.
J	The computer retransmits the second half of the part program.
K	The N. C. responds with an affirmative acknowledgment.
L	The computer releases the communication line.

TRANSMITTING PART PROGRAM - N. C. TO COMPUTER

The computer or N. C. can initiate the up loading of a part program. If the host initiates the up loading, no operator intervention is required.

NOTE

Cycle Start cannot be active when up loading a part program.

The computer initiates up loading in the following manner.

Example: The computer wants part program number 0831978.

STEP	N. C.	COMPUTER
A		← ENQ
B	DLE 0 →	
C		← STX RNS ETX LRC
D	DLE 1 →	
E		← STX 0831978 ETX LRC
F	DLE 0 →	
G		← EOT
H	SOH N/C I. D. # ENQ →	
I		← DLE 0
J	STX part program I. D. # ETX LRC →	
K		← DLE 1
L	STX part program ETX LRC →	
M		← DLE 0
N	EOT →	

STEP	DESCRIPTION
A	The computer requests control of the communication line.
B	The N. C. sends an affirmative acknowledgment.
C	The computer sends a command message. The command message tells the communication software in the N. C. that the computer will request a part program from the N. C.
D	The N. C. sends an affirmative acknowledgment.
E	The computer releases the communication line.
F	The N. C. requests control of the communication line.
G	The computer sends an affirmative acknowledgment.
H	The N. C. requests control of the communication line.
I	The computer sends an affirmative acknowledgment.
J	The N. C. sends a part program I. D. number.
K	The computer sends an affirmative acknowledgment.
L	The N. C. sends the part program requested by the computer.
M	The computer receives the part program correctly and acknowledges affirmative.
N	The N. C. releases the communication line.

To initiate sending a part program by the operator to the computer, the following events must happen:

1. The operator sends the computer a message via the display asking that a command message be sent to the N. C. requesting a part program be up loaded.

2. The computer sends a command message to the N. C. asking for the part program.

3. The N. C. gives an affirmative acknowledgment.

4. The computer now takes the part program from the N. C. 's part program storage area.

STEP	N.C.	COMPUTER
A	Message keyed in and sent requesting a part program be removed. (Operator logging onto system.)	
B		← ENQ
C	DLE 0 →	
D		← STX RNS ETX LRC
E	DLE 1 →	
F		← ST 87778 ETX LRC
G	DLE 0 →	
H		← EOT
I	SOH N/C I. D. # ENQ →	
J		← DLE 0
K	SOH N/C I. D. # STX part program I. D. # ETX LRC →	
L		← DLE 1
M	STX part program ETX LRC →	
N		← DLE 0
O	EOT →	

STEP	DESCRIPTION
A	The N. C. operator keys in the message requesting up loading of a part program. At the same time, the operator is logging onto the system.
B	The computer requests control of the communication line.
C	The N. C. sends an affirmative acknowledgment.
D	The computer sends a command message requesting the part program.
E	The N. C. sends an affirmative acknowledgment.
F	The computer sends the part program I. D. number of the part program that the computer wishes to remove.
G	The N. C. sends an affirmative acknowledgment.
H	The computer releases the communication line.
I	The N. C. requests control of the communication line.
J	The computer sends an affirmative acknowledgment.
K	The N. C. sends its own I. D. number along with the part program I. D. number.
L	The computer sends an affirmative acknowledgment.
M	The N. C. sends the part program.
N	The computer sends an affirmative acknowledgment.
O	The N. C. releases the communication line.

TRANSMIT MACHINE STATUS REPORTS

The Production Log/Machine Status message can be sent to the computer in one of two ways.

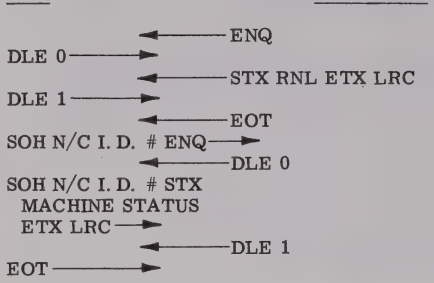
A. NON-POLLING - The N. C. sends the computer a machine status message (tentatively every 15 seconds) without the computer requesting the message.

The form of this message will be defined at a later date.

B. POLLING - Polling provides a larger amount of flexibility. The user customer can tally cycle starts, feedholds, program stops, end-of-program, and end-of-tape to name a few.

Custom software has to be written into the N. C. software to accommodate what the user customer wants to monitor.

Example: The host computer requests machine status.



APPENDIX A
COMMAND MESSAGES

The first message sent from the computer to the N. C. following an Establish procedure (ENQ) is a command message. The command information is between STX and ETX or in the data section of the message. The command message consists of 3 and, in some cases, 4 ASCII characters. The N. C. cannot send a command message but can only act on directives of the command message.

1st Character

R - Identifies a request for data from the N. C. After the N. C. receives a request for data and the data is identified, the N. C. attempts to locate and send the requested data back to the computer. The N. C. must go through an Establish procedure, even if it sends no data, before another request for data is issued.

S - Identifies that the computer is sending the N. C. some form of data. The data type is identified further in the command message.

2nd Character

N - Must be an N.

3rd Character

I - Indicates display. The first letter in the command message indicates whether the display would be Source (R) or Destination (S) of the data.

L - Indicates Production Log/Machine status. The first letter of the command message would have to be R.

S - Indicates Part Program Storage. The first letter of the command message indicates whether the computer would down load a part program to the N. C. (S) or request a part program from the N. C. (R).

4th Character

N - Indicates that a reply will not be requested.

Example: The computer sent a command message (SNDN) followed by a message for the display. The N. C. operator sees the message on the display and could reply to the computer via protocol without having the computer sending another (RNI) command message.

Y - Indicates that a reply is requested.

Example: The computer sends a command message (SNIY) followed by a message for the display. The N. C. operator sees the message on the display, keys in a reply message, and pushes the Punch/Send pushbutton. The display goes blank, but the Punch/Send pushbutton remains lit until the computer sends a command message (RNI) requesting data from the display.

APPENDIX B
BINARY SYNCHRONOUS COMMUNICATION CHARACTERS

DLE 0 DLE 1 (Affirmative Acknowledgment): ASCII 10 30, 10 31

Indicates that the previous transmitted block was accepted by the receiving station and that the receiving station is ready to accept the next block of transmission. ACK 0 and ACK 1 alternate, providing sequential checking control for a series of replies.

DLE (Data Link Escape): ASCII 10

A control character used exclusively to provide supplementary line-control signals. DLE 0, DLE EOT

ENQ (Enquiry): ASCII 05

Transmitted as part of an establish sequence, bid for control of the communication line.

EOT (End of Transmission): ASCII 04

Indicates the end of a transmission which may include one or more messages. An Establish procedure must then be performed before data can again be sent and received in the Binary Synchronous mode.

ETX (End of Text): ASCII 03

Indicates the end of a message. The LRC character is sent immediately following ETX. ETX requires a reply indicating the receiving station status.

LRC (Longitudinal Redundancy Check):

The LRC character is accumulated at both the sending and receiving stations during the transmission of a message via protocol. The first character of the message, SOH or STX, clears a seven-bit LRC accumulator. Each succeeding character up to and including the ETX is exclusive ORed with the LRC and the results returned to the LRC. The LRC is transmitted immediately following an ETX to the receiving station.

NAK (Negative Acknowledgment): ASCII 15

Indicates that the previous transmitted block was found to be in error by the receiving station and should be retransmitted.

SOH (Start of Heading): ASCII 01

Precedes a block of heading characters.

STX (Start of Text): ASCII 02

Indicates the start of a message.

NOTE
All ASCII characters are hexadecimal.

INDUSTRIAL CONTROL DEPARTMENT, GENERAL ELECTRIC COMPANY, WAYNESBORO, VIRGINIA

CHAPTER IV
PART PROGRAMMING

GEK-45675C

PART PROGRAMMING FOR THE 1050T CONTROL

November, 1978

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These instructions do not purport to cover all details or variations in equipment nor to provide for every possible contingency to be met in connection with installation, operation or maintenance. Should further information be desired or should particular problems arise which are not covered sufficiently for the purchaser's purposes, the matter should be referred to General Electric Company.

SECTION 1
GENERAL TAPE CODING INFORMATION

The Mark Century 1050T Control is a two-axis, continuous path, contouring Control. It accepts information from a 1 inch wide tape, and converts this information into output signals to a machine. The output signals control the machine tool functions or operations. Tape information is converted into commands for:

1. Machine tool movements in the form of straight lines, slopes, and arcs.

2. Machine tool non-motion periods referred to as "dwell" periods.

3. Machine tool rates of movement. The rate which the tool member moves is referred to as feed rate.

4. Tool selection (e.g., a machine turret is positioned for the selection of different tools for metal cutting.)

5. Machine spindle motion. The rate of rotation of the spindle for proper cutting is referred to as spindle speed (rpm - revolutions per minute).

6. Machine auxiliary functions such as turning the coolant liquid on and off or selecting the direction for the spindle to rotate.

Tape Specifications

The tape (Figure 1) used with the Control is *EIA Standard 1 inch wide 8 channel (or track) tape. The tape should meet the specifications of EIA Standards RS-244, RS-227, RS-358 (optional) and **NAS-943 and NAS-955.

The tape material used is paper, plastic, or a plastic coated tape which is identified by the E.I. DuPont de Nemours Company tradename of Mylar. The tape must be at least 70% opaque since a photoelectric tape reader is used. If paper tape is used, the color must be black.

Certain tapes are available which have one silver-colored side. This type of tape is not recommended. If it must be used, however, the silver side must be

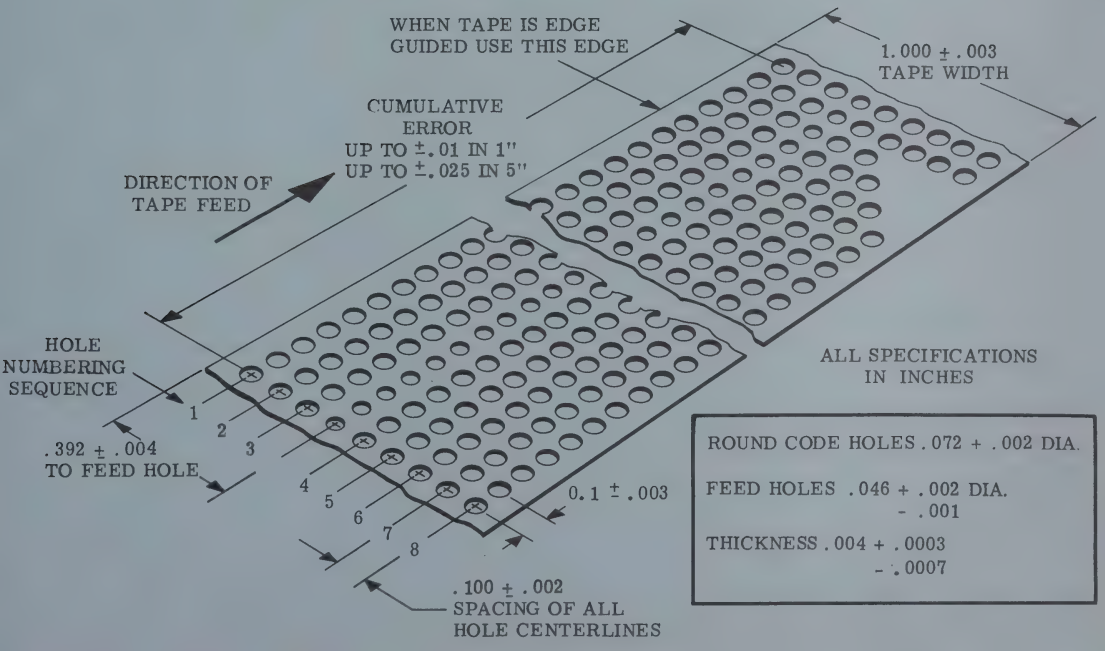


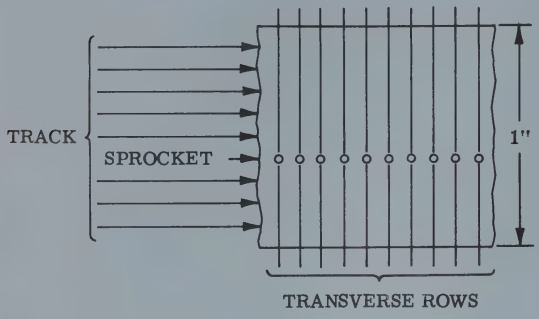
Figure 1

*Electronic Industries Association
**National Aerospace Standards
Ref. 48-59

facing up as it passes through the reader head to avoid excessive light reflection into the photosensing area.

TAPE ARRANGEMENT

Information on the tape is in the form of punched holes which are arranged in tracks and transverse rows as shown below.



The width of the tape is divided into 9 regions, 8 of which are designated as "tracks" and a ninth for the drive sprocket holes. Five data tracks are on one side of the sprocket track, and 3 on the other. The tracks are also referred to as "channels". The holes are punched in the tape exactly on the center lines of the tracks.

The length of the tape is divided into regions, the center lines of which are designated as "transverse rows". The distance between the transverse rows is 0.1 inch. The holes are punched exactly on the center lines of the transverse rows. Each transverse row contains 8 tracks. Holes are punched in various tracks of a transverse row. The tape reader reads one transverse row of data at a time which is a code for one "character". The coding for the punched holes is either EIA Standard RS-244* "A" or RS-358*

Character

A "character" is any single piece of information. It can be:

1. A letter of the alphabet
2. A single digit
3. Punctuation
4. Plus or minus signs
5. Special symbols

Each transverse row contains in its 8 tracks the coded information for one character. The tape reader reads one character at a time. A group of characters make up a "word" of information.

Word

A word is usually a set of characters comprised of a letter and one or more numbers, which gives the Control a single instruction. For example, g01 is a preparatory word; x123456 is an x distance word. The word can also be a single character, such as EOB (end-of-block) or EOR (end-of-record).

Block

The block is composed of a word or group of words. A "block" of coding contains all of the information necessary to perform one operation. This information may be contouring information only, or contouring and auxiliary information, or auxiliary information only.

PARITY

Many different types of coding systems exist for recording information on punched tape. Two of these systems may be used in the Mark Century 1050T Control. They are RS-244 and RS-358. Both of these codes are described in detail in this section. Although the coding for any individual character is different between the two codes, both codes use a parity check system. That is, one of the eight tracks available for use is used as a parity channel. This channel is either punched or not punched so that the total number of holes in any transverse row is either an even or an odd number. If the Parity channel makes the total number of holes in the row an even number, then the code is said to have "even parity". If the parity channel is used to make the transverse row have an odd number of holes, the code is said to have "odd parity".

*Electronics Industries Standard Code Numbers

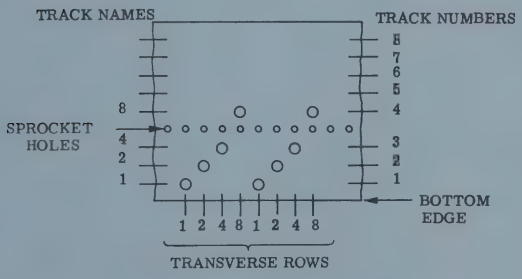
This parity system is used as a check to aid in determining if the punch and reader are operating correctly. If data input is set up for odd parity, and it reads a traverse row with 4 holes, for example, the reader will stop and a reader error will be indicated on the display.

RS-244 coding uses odd parity, and the parity channel is track 5. RS-358 coding has even parity, and the parity channel is track 8. In the following detailed description of these codes, the parity channel is understood to be either punched or not, depending on the requirement of that character code, unless otherwise stated.

TAPE CODE RS-244

RS-244 uses odd parity with track 5 as the Parity channel.

In RS-244 the tape codes for numbers one through nine are the Binary Coded Decimal (BCD) system. (Refer to Interpretation of Logic Diagrams GEK-45677). In this system the 8 tracks are numbered from the bottom edge of the tape. The weighted numerals 1, 2, 4, 8 are assigned to tracks 1, 2, 3, 4 respectively (see figure below.)



Thus, the following conditions are established: A transverse row with a:

Hole in track 1 only indicates the numeral 1

Hole in track 2 only indicates the numeral 2

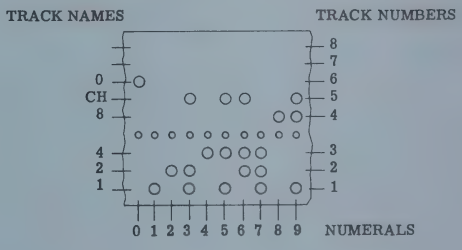
Hole in track 3 only indicates the numeral 4

Hole in track 4 only indicates the numeral 8

The complete set of numerals from 1 to 9 is obtained by using combinations (additions) of the above numerals. Numeral zero is represented by a hole punched in track 6. The method is as follows:

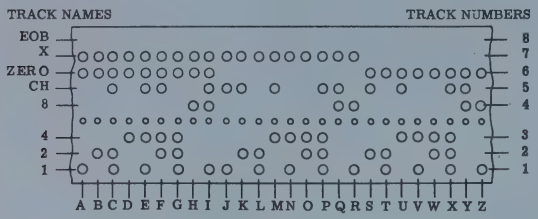
Numeral	Binary Coded Decimal System	Tracks Punched	Parity Track Punched
1	1	1	No
2	2	2	No
3	2+1	2 and 1	Yes
4	4	3	No
5	4+1	3 and 1	Yes
6	4+2	3 and 2	Yes
7	4+2+1	3,2 and 1	No
8	8	4	No
9	8+1	4 and 1	Yes
0	0	6	No

On tape it appears as shown below:



Track 6 and/or 7 of the tape is used with combinations of the numeral codes to indicate the letters A through Z.

The following figure shows the coding for the letters of the alphabet:



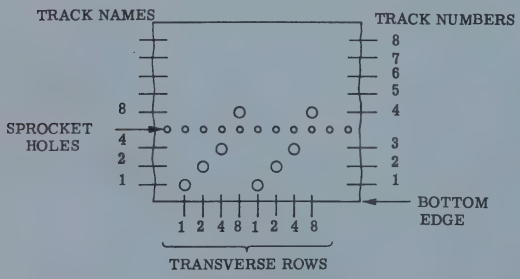
The punctuation Carriage Return (end-of-block) is assigned to track 8 on the tape. In programming with a keyboard printer, this code character is automatically punched in track 8 by pressing the Carriage Return key. Refer to the next section for more information on the EOB character.

Figure 2 (page 7) shows a section of tape illustrating characters, etc. The coding for all of the RS-244 characters is shown in Figure 3 (page 8).

TAPE CODE RS-358

Tape code RS-358 uses even parity with track 8 being the parity track.

The number code used with RS-358 is the Binary Coded Decimal (BCD) system. (Refer to Interpretation of Logic Diagrams GEK-45677). In this system, the 8 tracks are numbered from the bottom edge of the tape. The numerals 1, 2, 4, 8 are assigned to tracks 1, 2, 3, 4 respectively as shown below.



The following partial conditions for numbers are established: A transverse row with a:

Hole in track 1 indicates the numeral 1

Hole in track 2 indicates the numeral 2

Hole in track 3 indicates the numeral 4

Hole in track 4 indicates the numeral 8

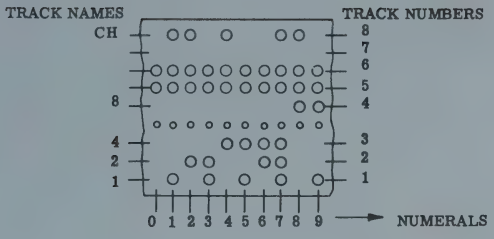
No holes in track 1, 2, 3, 4 indicates the numeral 0.

The complete set of numerals from 1 to 9 is obtained by using combinations (additions) of the above numerals. The method is as follows:

Numeral	Binary Coded Decimal System	Tracks Punched	Parity Track Punched
0	0	5,6	No
1	1	1,5,6	Yes
2	2	2,5,6	Yes
3	2 + 1	1,2,5,6	No
4	4	3,5,6	Yes
5	4 + 1	1,3,5,6	No
6	4 + 2	2,3,5,6	No
7	4 + 2 + 1	1,2,3,5,6	Yes
8	8	4,5,6	Yes
9	8 + 1	1,4,5,6	No

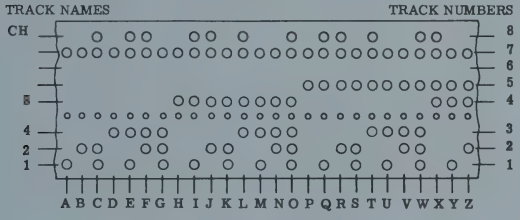
On tape it appears as shown on page 5.

RS-358 tape coding system is different from RS-244 in that other tracks are punched to comprise the numbers 0 to 9. These holes are added in tracks 5, 6 and 8 (parity) shown on Figure 5 (coding of all characters of RS-358). Both tracks 5 and 6 have holes to differentiate between numbers and letters.



Track 7 of the tape is used with tracks 1 through 5 to indicate the letters A through Z. Numerals and other special characters do not use track 7.

The following figure shows the coding for the letters of the alphabet in RS-358 code.



The punctuation end-of-block is assigned to track 2 and 4 on the tape. End-of-Block is a character used in the tape code to indicate the completion of a "block" of information as previously defined. It is generated by depressing the Line-Feed (LF) key. Set the machine so that when the Carriage Return key is depressed, both the Line Feed and Carriage Return (CR) characters are punched. This assures that the typewriter carriage returns at the end of each block. Refer to the next section for further information on the EOB code.

Two tape codes, Control Out and Control In, are included in the EIA standard RS-358 code. These codes are indicated by opening and closing parenthesis respectively:

Control Out (

Control In)

The Control Out function directs the Control to ignore all data until the Control In function is read. (Note that a Rewind Stop code should not be used between parentheses). Typically, the Control Out and Control In functions are used to enclose machine operation information on the printout or operator instructions on the display.

Figure 4 (page 8) shows a section of tape illustrating words and blocks. The coding for all characters of RS-358 is shown on Figure 5 (page 9).

An asterisk denotes the characters recognized by the 1050T Control.

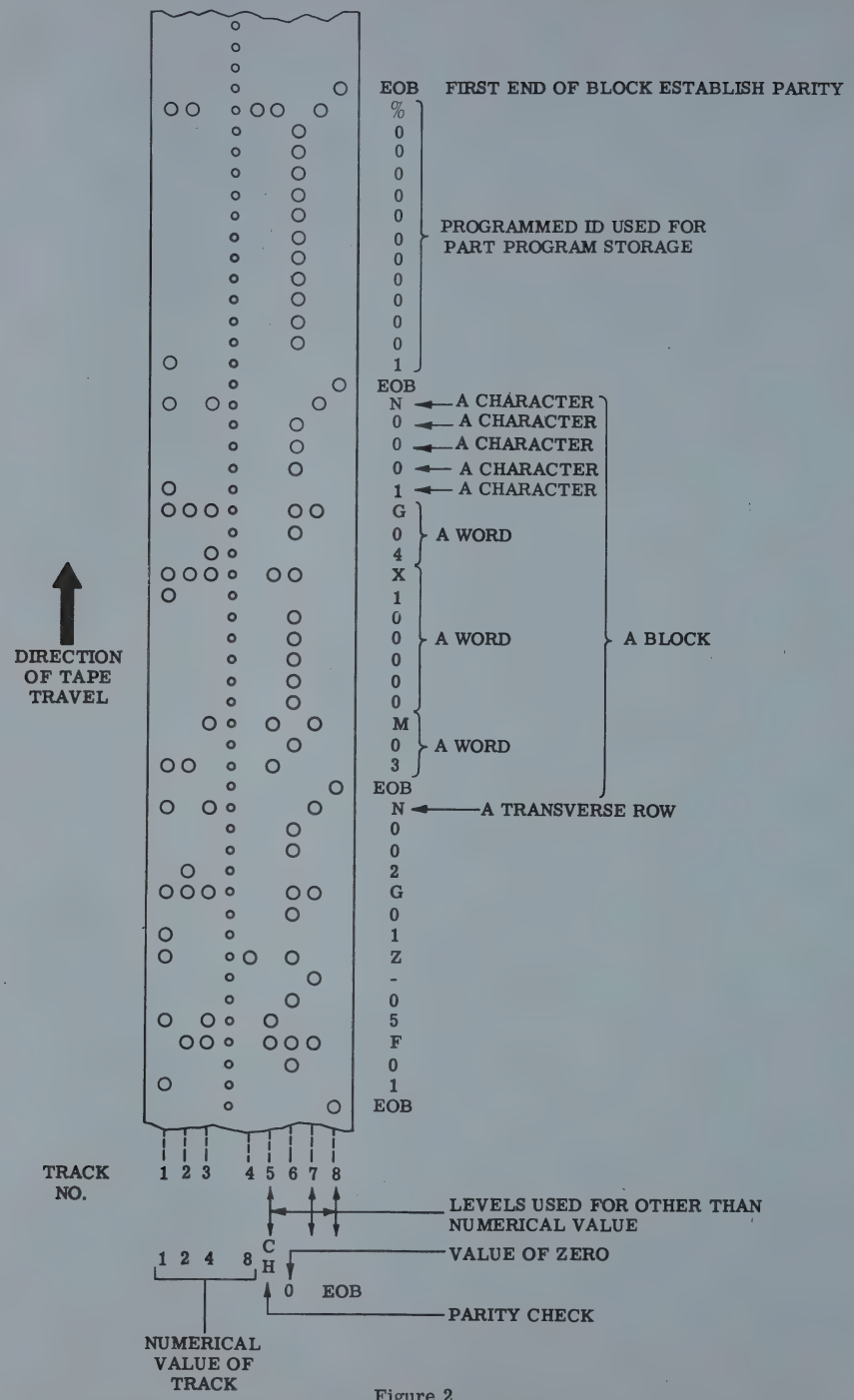


Figure 2.
RS-244 TAPE ILLUSTRATION

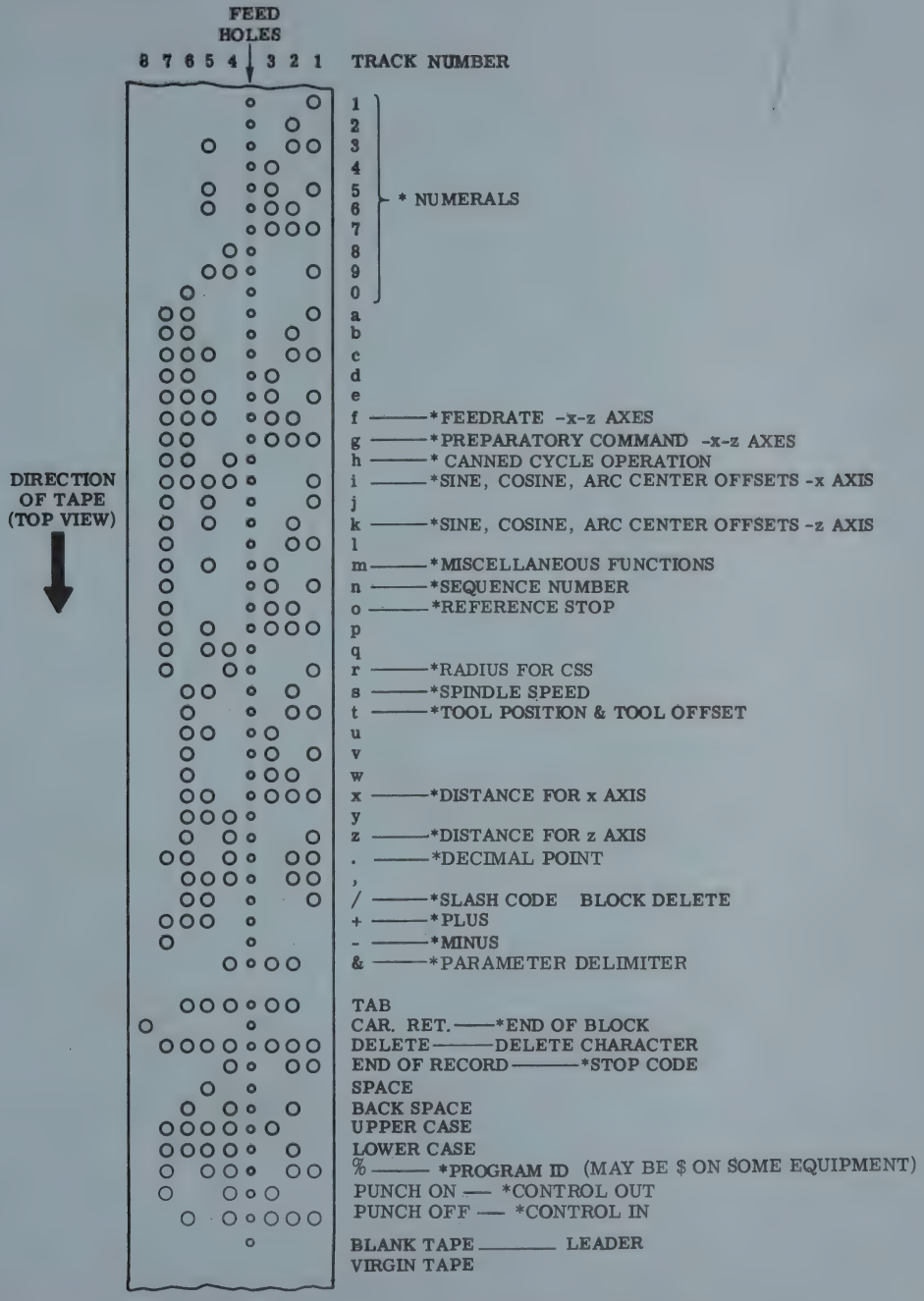


Figure 3.
EIA RS-244 DENOTING CHARACTERS
ACCEPTED BY 1050T CONTROL (*)

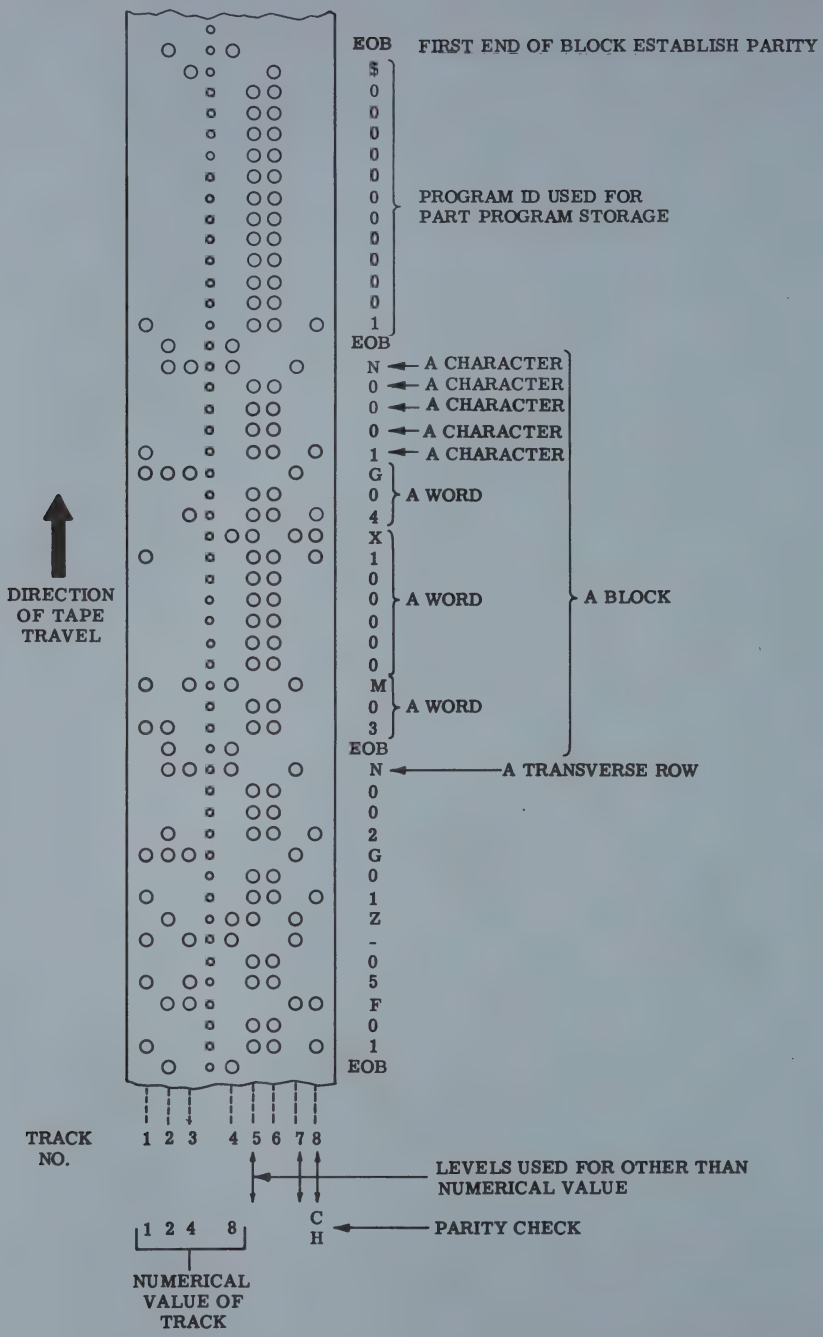
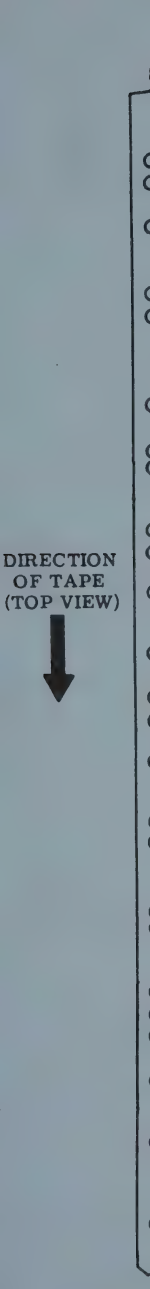


Figure 4.
RS-358 TAPE ILLUSTRATION



0
1
2
3
4
5
6
7
8
9
* NUMERALS

A
B
C
* DISTANCE FOR ADDITIONAL AXIS (OPTIONAL)

D _____
E _____
F _____ *FEEDRATE x-z AXES
G _____ *PREPARATORY COMMAND -x-z AXES
H _____ *CANNED CYCLE OPERATION
I _____ *SINE, COSINE, ARC CENTER OFFSETS - x AXIS
J _____
K _____ *SINE, COSINE, ARC CENTER OFFSETS - z AXIS
L _____ *SUBROUTINE IDENTIFIER
M _____ *MISCELLANEOUS FUNCTIONS
N _____ *SEQUENCE NUMBER
O
P
Q
R _____ *RADIUS FOR CSS
S _____ *SPINDLE SPEED
T _____ *TOOL POSITION & TOOL OFFSETS
U _____
V _____
W _____
X _____ *DISTANCE FOR x AXIS
Y _____
Z _____ *DISTANCE FOR z AXIS
DEL ____ DELETE
BS _____ BACK SPACE
HT _____ HORIZONTAL TAB
LF _____ *LINE FEED — USED FOR END OF BLOCK
CR _____ CARRIAGE RETURN
SPACE
% _____ *PERCENT — USED FOR WIND/REWIND STOP
(_____ *OPENING PARENTHESIS — USED FOR CONTROL OUT
) _____ *CLOSING PARENTHESIS — USED FOR CONTROL IN
+ _____ *PLUS
- _____ *MINUS
/ _____ *SLASH — USED FOR BLOCK DELETE
: _____ *COLON — USED FOR REFERENCE STOP
. _____ *DECIMAL POINT
$ _____ *DOLLAR SIGN — USED FOR PROGRAM ID
; _____ *SEMI-COLON — PARAMETER DELIMITER
BLANK TAPE
VIRGIN TAPE

Figure 5.
RS-358 DENOTING CHARACTERS
ACCEPTED BY THE 1050T Control (*)

SECTION 2
GENERAL PROGRAMMING INFORMATION

The Mark Century 1050T Control System is a 2-axis continuous path computer numerical contouring control. The Control allows the programmer to act as the machine operator and to command the sequence of operations necessary to machine a particular workpiece. By referencing a detailed drawing of the workpiece, the programmer can enter on a manuscript the required dimensions and other necessary data, such as speeds and feeds, in a line-by-line fashion to establish the sequence of machine operating commands. Normally, one line or block of information represents one describable operation or several independent describable operations. (Turning the coolant on and selecting the spindle speed are independent operations which can be commanded in the same block).

Dimension command codes are the primary part of a programming manuscript. Other codes include commands for control of feed rates, spindle speeds, tool offsets, operating modes, and various miscellaneous functions.

NOTE: Acceptable programming can be obtained only if the rules and regulations applicable to the Control system are followed.

Subsequent sections of this instruction will acquaint the reader with programming information and the programming rules that apply to the Mark Century 1050T Control system.

Programming instructions for the Mark Century 1050T Control system require both letters and numerals which constitute a program word. The 1050T Control has a "word address" system. A letter is the word address and the numerals are the word contents or value. Thus, "n1999" is one word of information with address "n" and contents "1999." The programming format is the total number of letter addressed words that the Control can accept.

PROGRAMMING FORMAT

The Mark Century 1050T format which has been prepared in accordance with EIA Standard RS-274 is as follows:

Format Classification Shorthand

Inch	Metric
c210.534.22	c210.543.22

Format Detail

Inch n4.g2.x±34.z±34.i34.k34.r34.f32.s4.t4.h2.m2. EOB

Metric n4.g2.x±43.z±43.i43.k43.r43.f41.s4.t4.h2. m2.EOB

(Feedback: .1" or 2mm)

NOTE:

1. The standard dimension word format of ±34 (Metric ±43) may be changed by Machine Setup Data* to ±24 (Metric ±33).

2. The s format can be s2, s3, or s4.

3. If the inches-per-revolution feedrate is used, f becomes f04 for Inch and f13 for Metric.

PROGRAMMING SEQUENCE

The punched tape programming sequence is as follows:

1. Leader: 10 inches for fan fold or loop tape; 8 feet if reels are used.

2. Stop character.

3. A few inches of tape feed.

4. End-of-Block (EOB) character.

The first End-of-Block code establishes parity checking. This character must precede the first program word.

5. Program ID (for Part Program Storage option). Program ID consists of an ID character followed by up to 12 alphanumeric characters.

6. End-of-Block (EOB) character.

7. Letter address characters and number characters (program word) as required. It is recommended that the letter address characters, as required, are programmed in the order shown under Format Detail.

8. End-of-Program command (m02 or m30).

9. End-of-Block character.

*Machine Setup Data software is used to make several setup selections at the time of installation.

10. Stop character.

11. Trailer: 10 inches for fan fold or loop tape; 8 feet if reels are used.

MISCELLANEOUS PROGRAMMING NOTES AND DIRECTIONS

1. Tab codes may be used to separate format words and decimal points may be used in dimension words. This provides a more easily read printed output from the tape punching equipment. If the tab code or decimal point is used, the Control logic system ignores the tab character and decimal punches in the tape.

2. Not all words are retained in memory after execution of a block. A word entry that is read, executed, and then cancelled, is called a one-shot command.

3. Information in registers n, g, f, s, t, and m is retained from block to block until new information is read. It is not necessary to repeat these words in all blocks unless there is a change of word contents (except g92 which is a one-shot command).

4. The standard tape reader reads at a rate of 150 characters per second. The optional tape reader reads at a rate of 300 characters per second.

5. Make sure that word addresses are not repeated within any one block (that is, the same letter is not used more than once in a block of data).

6. Word commands, whether retained or one-shot are cancelled by clearing the system logic storage with the Clear pushbutton. The programmer should not assume that retained commands are carried over from one program to the next; therefore, the first few blocks of information for a program must include the necessary entries to establish correct operating conditions.

7. Information may be typed in the leader of the tape provided end-of-block characters are not included.

8. The x, and z entries must be preceded by a minus sign if negative. A plus sign is assumed by the Control if no sign is entered.

9. If a loop tape ends with an m01 and there is more than 7 inches of leader between the two ends of the program, there must be a stop code at least every 7 inches. Otherwise a READ ERROR message will be displayed.

10. For some types of spindle controls, when a change in spindle direction is required, it is necessary to program a spindle stop (m05) before programming the new spindle direction.

11. The Control can be MSD set up for either omit leading or trailing zeros. All letters are affected. Example of omit trailing zeros: x123000 can be programmed as x123. Example of omit leading zeros: x000456 can be programmed as x456.

12. Do not program the nondwelling axis (z) during a dwell (g04).

13. Do not include stop characters within part programs to be stored in memory. A unique part program ID is required following each stop character.

SPECIAL PROGRAMMING CHARACTERS

There are seven special programming characters.

Function	RS-244	RS-358
End-of-Block	CR	LF
Block Delete	/	/
Stop	EOR	%
Reference Stop	O	:
Control Out	Punch On	(
Control In	Punch Off	)
Program ID	%	$

End-of-Block

The End-of-Block character is programmed with a Carriage Return (CR) character in the EIA RS-244 code, and with a line Feed (LF) character in the EIA RS-358 code.

When punching a tape using the RS-358 code, use the CR (Carriage Return) key to obtain the End-of-Block character. Set the machine so that when the CR key is depressed, both the LF (Line Feed) and the CR characters are punched sequentially. The machine

punches the CR characters first followed by the LF character. This assures that the carriage returns at the end of each block of data. The LF character is recognized as an End-of-Block signal; the CR character is not recognized by the Control when in the RS-358 mode.

This character must precede the first block of meaningful information in RS-244 or RS-358 since the EOB character activates the parity check logic within the Control.

Block Delete

When a slash (/) character precedes the first character in the letter address of a block, the tape reader ignores all tape information until the next End-of-Block code, if the Block Delete switch has been actuated.

Stop

The Stop code is programmed with the "End-of-Record" character in the RS-244 system, and with the "%" character in the RS-358 system.

Reference Stop

The Reference Stop code is programmed with the letter "O" in RS-244 and a colon ":" in RS-358. It can be used to replace the letter n in the reference stop block or may be in a block by itself. The block identified by the reference stop code is placed in buffer at the end of the reference stop operation.

Control Out and Control In (Operator messages)

Operator messages may be included in a part program by using the Control Out and Control In tape codes. These codes are indicated by open and close parenthesis in RS-358 code or Punch On and Punch Off in RS-244 code.

These characters allow the insertion of instructional messages in the tape. The block of tape containing the message may contain a sequence number but must not contain any other command words outside the control out, control in characters. The format for this block of tape should be: sequence number, control out character, message (up to 32 characters), control in code, and EOB character. In order to prevent possible mis-operation of the Control, the message must not contain (,), %, :, or line feed. The message is displayed when read and remains displayed until it is replaced by another message read from tape, an error message, or data requested by changing the display selector switch. If several tape messages are to be displayed sequentially, a dwell should follow each message to assure that the message is displayed long enough to be read.

Program ID Character

The program identification character is programmed as a % character in RS-244A and as a $ character in the RS-358 code sets. The program ID which follows this character may contain up to 12 alphanumeric characters and is left justified. When the program ID is used, it must be the first information following the first EOB in the tape.

SECTION 3
DATA WORD ENTRIES

Data words for the Mark Century 1050T Control are:

Sequence number
Preparatory command
Distance commands (axis data)
Feed function
Arc center offsets
Spindle speed
Tool position and tool offset
Miscellaneous functions

A detailed description of these words follows:

SEQUENCE NUMBER

Program the sequence number with letter "n" and 4 digits (0000 to 9999). The sequence number is displayed until another number is read if the optional Sequence Number readout function is a part of the Control or until the Clear pushbutton is depressed, resetting the Control.

If the Optional Sequence Number readout is not a part of the Control, the programmer can still program the sequence number to identify the blocks of data in a program. N can be selected in the Universal readout.

It is suggested, but not essential, that all sequence numbers be in numerical order. The same sequence number may be carried for several blocks; however, failure to number each block and lack of numerical order makes sequence number search more difficult.

In the Sequence Number Search mode with the optional Sequence Number readout, the sequence number being searched for is displayed in the optional readout and the number being read can be displayed in the Universal readout.

The optional 4-digit readout display of the sequence number is mounted on the main Operator's Station so that the operator can check the operation being performed against the manuscript. The readout exhibits the last sequence number read.

The sequence number readout can be cleared by operating the Clear pushbutton.

PREPARATORY COMMAND

The preparatory command sets up the Control for different types of automatic machine operations. Program each preparatory command with letter address g and 2 digits. When any g command of group 1 in the following table is read, it is retained until changed by a new command of that group or until cleared. It will be cleared upon reading a g command of another group or performing a clear operation. When a g command of any other group is read, it is retained until it is changed by a new command of the same group or until a clear operation is performed.

The g92 (register preset) is not retained. Some additional factors apply to a few codes, and these will be noted in the text.

A Table showing each g command and a brief description of its function is given below.

Table 1.
PREPARATORY COMMANDS

GROUP	COMMAND	FUNCTION
1	g01*	Linear interpolation
	g02	Circular interpolation, clockwise arc.
	g03	Circular interpolation, counterclockwise arc.
	g04	Dwell
	g21	In-position zone linear interpolation
	g22	In-position zone circular interpolation, clockwise arc
	g23	In-position zone circular interpolation, counterclockwise arc
	g33	Threadcutting constant lead
	g34	Threadcutting increasing lead
	g35	Threadcutting decreasing lead

*The Control is shipped with this command assumed upon startup and after a clear operation.

Table 1.
Continued

GROUP	COMMAND	FUNCTION
2	g70 + g71	Inch data input Metric data input
3	g90 g91 +	Absolute data input Incremental data input
4	g92	Register preset (non-retained)
5	g94 + g95	Inches-per-minute (ipm) programming Millimeters-per-minute (mmpm) Inches-per-revolution (ipr) programming Millimeters-per-revolution (mmpr)
6	g96* g97*+	Constant surface speed Direct revolutions-per-minute programming

INTERPOLATION PREPARATORY COMMANDS

The Control has provision for the following interpolation preparatory commands: g01, g02, g03, g21, g22, g23.

In circular interpolation (g02, g03, g22, or g23), to determine whether an arc is clockwise or counterclockwise in accordance with the EIA Standard for Circular Interpolation, view the plane of motion in the negative direction of the perpendicular axis. If the curvature of the path of the tool with respect to the workpiece is clockwise, the arc is referred to as a clockwise arc. If this curvature is counterclockwise, the arc is referred to as a counterclockwise arc. A non-EIA definition may be selected by Machine Setup Data.**

The in-position zone commands (g21, g22, and g23) operate the same as the corresponding commands g01, g02, and g03 with the addition that the transfer of the next block of information is held up past distance zero on each axis until the servo lag is reduced below a preset limit. The preset limit may be selected by Machine Setup Data as any value up to 0.0255 inch (0.511 mm).

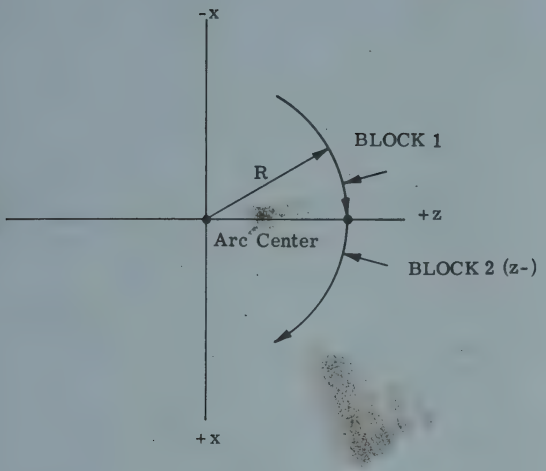
Although use of the in-position zone commands may increase the cycle time slightly, they will reduce the corner rounding sometimes encountered at high speeds.

When arcs are programmed the zero coordinates cannot be crossed in a single block of information. For example, the arc below would require 2 blocks of information.

* The Control does not respond to these commands unless the appropriate option is installed.

\+ The Control is shipped with these commands assumed upon startup and after a clear operation. The Control can be changed by Machine Setup Data (MSD).

** Machine Setup Data software is used to make several setup selections at the time of installation.



DWELL COMMAND

Program dwell with preparatory command g04 and the desired magnitude of dwell under the x address in seconds. This dwell command permits the machine axes to remain motionless for the programmed period of time. The dwell format is 2.4 for six-digit systems and 3.4 for 7-digit systems, for both Inch and Metric programming. If Machine Setup Data is set up for 6-digit Inch and 7-digit Metric, the dwell format is 2.4 in the Inch mode and 3.4 in the Metric mode. For example, g04x123456 results in a dwell of 12.3456 seconds when the dimension format is 6-digit.

Dwell can be programmed in terms of the number of spindle revolutions. For this feature the Control must be in the g95 mode (inches-per-revolution or millimeters-per-revolution programming). Program the dwell command with the preparatory command g04 under the x address. The x data is the desired magnitude of revolutions. The dwell format is 2.4 for six-digit systems and 3.4 for 7-digit systems, for both Inch and Metric programming. If machine setup data is set up for 6-digit Inch and 7-digit Metric, the dwell format is 2.4 in the Inch mode and 3.4 in the Metric mode. For example, g04x123400 results in a dwell of 12.3400 spindle revolutions when the dimension format is 6-digit.

A Machine Setup Data change can be made which will force the Control to dwell only in terms of seconds.

THREADCUTTING COMMANDS

Program the threadcutting preparatory command g33, 34, or 35 followed by the necessary data for the thread. (See the Threadcutting Programming Section, page 28.)

INCH/METRIC SELECTION

Program Inch data input format with a g70 preparatory command. Program Metric data input format with a g71 preparatory command. Always put g70/g71 in a block by itself. The Control stays in the programmed mode regardless of other g commands until the other (g70 or g71) code is programmed or until a Clear operation occurs. After a Clear operation, the mode selected by Machine Setup Data is assumed.

ABSOLUTE/INCREMENTAL SELECTION

Dimension data commands and their functions are described below.

Incremental Data Input

In this mode, the dimension data (x-z) is programmed as distance to go and direction. Program as if the x-z axis zeros are established at the termination of the previous block.

The Control operates in this mode when a g91 preparatory code is programmed. The Control automatically reverts to the g91 mode when the Clear pushbutton is depressed.

Absolute Data Input

The Control stays in this mode regardless of other g commands until a g91 code is programmed or until the Clear pushbutton is depressed.

Dimension words must not be programmed in the block with g90 or g91. However, non-dimensional words can be programmed in the same block with these g commands.

Example: n000 g90f1 s20 m08
g90 m09

Program the Absolute Data Input mode with a g90 preparatory command. When the Control is in the Absolute Data Input mode, program all information in a motion command block exactly as you program incremental data, except for putting the x and z words in the form of absolute coordinates. If an axis address is omitted from a block, there will be

no movement of that axis. This is equivalent to reprogramming the present axis dimension. Remember that plus and minus signs now represent the Cartesian coordinate quadrant of operation rather than the direction of motion.

REGISTER PRESETTING

Preset the position registers with a g92 followed by the dimension words containing the desired position.

Non-dimension words (such as f, t, m) must not be programmed in the same block with a g92. The g92 code is not retained from block to block.

An example of proper preset programming:

It is desired to preset the position registers to x-01", z+01"

n001g92x-01z01EOB

FEED FUNCTION SELECTION

G94 is used for inch-per-minute (ipm) and millimeters-per-minute (mmpm) programming, and g95 is used for inch-per-revolution (ipr) and millimeters-per-revolution (mmpr) programming.

The Control will select either ipm, mmpm or ipr, mmpr operation depending on the Machine Setup Data selection when the Control is turned on or when the clear operation occurs. See ipr/mmpr feed, (Figures 6-9, pages 19 and 20) for further programming information for these commands.

CSS/DIRECT RPM SELECTION

Program constant surface speed using the g96 preparatory command followed by the necessary data in the s word.

Program direct revolutions-per-minute of the spindle using the g97 preparatory command followed by the necessary data in the s word. (See the Constant Surface Speed and Direct RPM Spindle Control section, page 38).

DISTANCE COMMANDS

Program the distance command for each axis in which there is to be motion, with the appropriate letter address (x,z) the appropriate sign if required to establish direction, and 6 or 7 digits as selected by Machine Setup Data, to establish the distance to be traveled. A 6-digit inch system will be used for illustration in the text.

Plus signs need not be programmed since the absence of a sign is understood by the Control as a plus. Program all minus signs. Trailing or leading zeros may be omitted depending on Machine Setup Data selection. Examples of both types of programming are given in Table 2, page 17.

Table 2.
PROGRAMMING WITH OMIT LEADING ZEROES AND
PROGRAMMING WITH OMIT TRAILING ZEROES

Examples:

MODE OF OPERATION	x DIMENSION OR DEPARTURE	OMIT TRAILING ZEROES	OMIT LEADING ZEROES
1. inch	-21.5 inches	g01x-215	g01x-215000
2. inch	0.0268 inch	g01x000268	g01x268
3. metric	-21.5 mm	g01x-0215	g01x-21500
4. metric	.268 mm	g01x000268	g01x268

x AXIS DATA

Inch (Machine Setup Data Selectable) x±24 or ±34

Metric (Machine Setup Data Selectable) ±33 or ±43

Data with letter address "x" is used for x axis moves which may be programmed in an incremental or absolute mode, for presetting the x position register and for programming dwell times.

The decimal point location in x data is understood; therefore, it is not necessary to program it. However, if the programmer wishes to include the decimal point in his program for clarification, he may. The Control ignores it.

Incremental Data Input

When the Control is operating in the Incremental Data Input Programming mode (g91), the x command dimension is the actual directional departure distance between the last commanded position of x and the new commanded position. With incremental data input, the sign (plus or minus) indicates direction of motion along the commanded axis.

Absolute Data Input

When the Control is operating in the g90 mode, the commanded dimensions represent absolute data. Remember that with absolute position data input, the sign (plus or minus) of the dimension refers to the direction from zero and not to the direction of motion.

For example, if the x departure is to be +5 inches from the zero reference point, the program for x is g01x05. If x is then to move back toward zero 1.0 inch, it is still a plus movement with respect to the zero reference point since the desired x location is +4. The program is g01x04. If x is then to move to the zero reference point, the program for x is g01x0.

The g01 code is programmed in each of the examples above. In normal operation the g commands are retained from block to block.

Dwell

When the active preparatory command is g04, the x dimension becomes a dwell time. The dwell data can be expressed in terms of seconds or in terms of spindle revolutions. See page 16 for detailed information.

z AXIS DATA

Inch (Machine Setup Data Selectable) ±24 or ±34

Metric (Machine Setup Data Selectable) ±33 or ±43

Data with letter address "z" is used for z axis moves. Dwell may not be programmed with z. All information under "x Axis Data" concerning incremental and absolute data also pertains to the z axis.

FEED FUNCTION

The feed word is a 5-digit number with the letter address f.

Three types of feed programming are available:

1. Traverse

2. ipm or mmpm - Inches or Millimeters-per-minute programming

3. ipr or mmpr - Inches or Millimeters-per-revolution programming

The programmer can select by g commands the type of feed programming (g94 for ipm or mmpm or g95 ipr or mmpr), or select traverse by a specific f word such as f9 which has been designated by Machine Setup Data. The traverse command may be any number from 00000 to 99999 but only the first four digits are significant.

An f code, once programmed, remains in storage until changed by another f code or cleared by m02, m30, or the Clear pushbutton. This is true even during g33 threadcutting blocks where f is not used.

If a traverse code is programmed in the ipr mode, it will temporarily force the ipm mode and the x and z axes will move at traverse rate until another f code is programmed which will again activate the ipr mode.

PROGRAMMED TRAVERSE FEEDRATE FUNCTION

The traverse code controls the x-z axes traverse. The traverse rate can be selected by Machine Setup Data and is independent of the high jog rate. The rate may be any rate up to 799.99 ipm or up to 16 mpm selected by Machine Setup Data. This fixed vectorial traverse rate will apply to the tool path. The manual feed override is made active or inactive for traverse in the Auto mode by Machine Setup Data. If f0 is established as the traverse code, the absence of an f code following Control on or depression of the Clear pushbutton does not produce the traverse rate until a new f code is programmed. Zero feed is the implied state of the Control system upon start up.

INCHES-PER-MINUTE OR MILLIMETERS-PER-MINUTE

Ipm or mmpm programming is the direct programming of the feed rate into the f command for the ipm or mmpm rate wanted. It is used for straight lines, slopes or arcs. Individual axis rates are adjusted to give a path rate equal to that programmed in the f command.

A g94 preparatory command selects ipm/mmpm programming.

Program the actual desired feed rate with the letter address f and a maximum of 5 digits. Rates are based on 100% Manual Feedrate Override. The Control has the capability of a 120% MFO operation. A minimum of 0.01 ipm and a maximum of 799.99 ipm (f00001 to 79999) is programmable.

Metric - minimum of 0.1 mmpm and a maximum of 9999.9 mmpm.

NOTE: Full programmed ipm or mmpm rate is obtained for all moves regardless of distance to be moved.

INCHES-PER-REVOLUTION OR MILLIMETERS-PER-REVOLUTION

Ipr programming is the programming of feed in terms of the spindle revolutions. It is used for straight lines, slopes or arcs.

For ipr/mmpr programming, feed is programmed in the range of .0001 to .9999 ipr and 0.001 to 9.999 mmpr for spindle speeds up to 4900 rpm.

The programmed values, which are retained, are path values. The Control automatically multiplies programmed feed by the spindle speed to obtain a feed rate. Just as in the case of the direct programming of inches-per-minute, individual axis rates are adjusted to give a path value equal to that programmed.

Maximum Feedrate Limits for ipr/mmpr

Figures 6, 6A, 7, and 7A, pages 19 and 20, show the maximum feed rates for ipr and mmpr programming, when the Control is set up to limit spindle speed override to 100% and for the Control set up to permit 120%. Feeds (and feedrates) equal to 120% of those shown can be obtained with 120% MFO.

ARC-CENTER OFFSET

Program arc-center offset with letter addresses "i" for x, and "k" for z, and 6 or 7 digits as selected by Machine Setup Data. There is no algebraic sign associated with arc-center offset. The choice of preparatory command is determined by the direction of the arc. As indicated in the figures on pages 19 and 20, i is the distance from the center of the arc to the starting point of the arc in the x direction; k is the distance from the center of the arc to the starting point of the arc in the z direction.

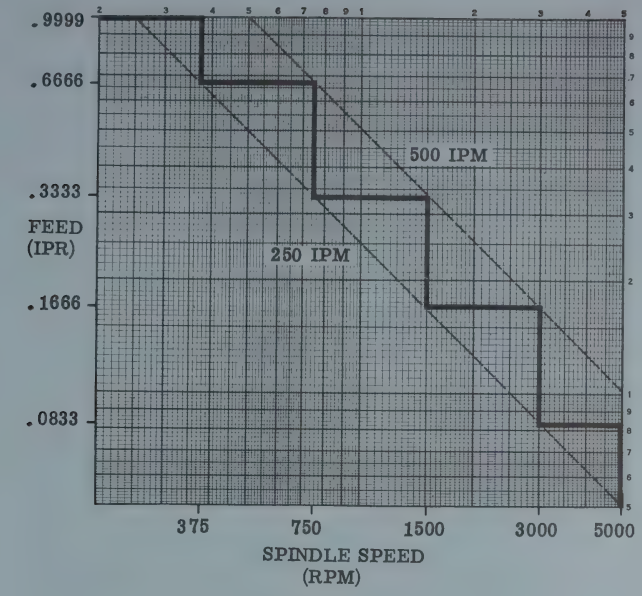


Figure 6.
MAX PROGRAMMABLE FEED (IPR) VS SPINDLE SPEED
FOR CONTROL WITH 50-100% SPINDLE SPEED OVERRIDE

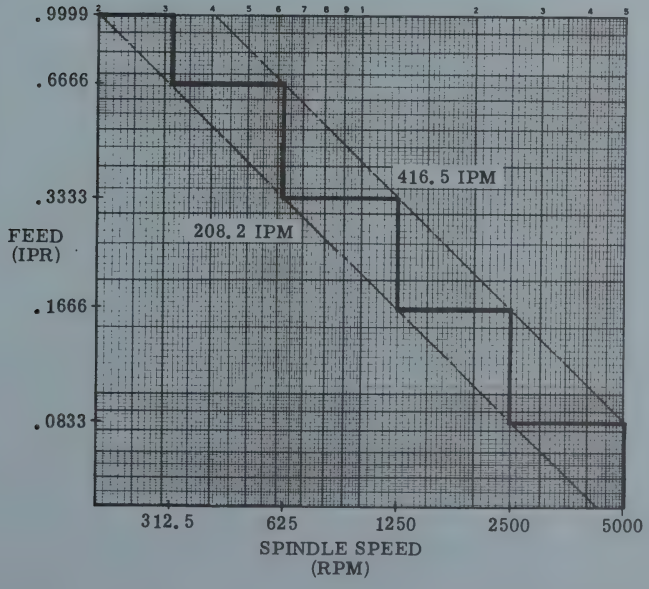


Figure 7.
MAX PROGRAMMABLE FEED (IPR) VS 100% SPINDLE SPEED
FOR CONTROL WITH 50-120% SPINDLE SPEED OVERRIDE

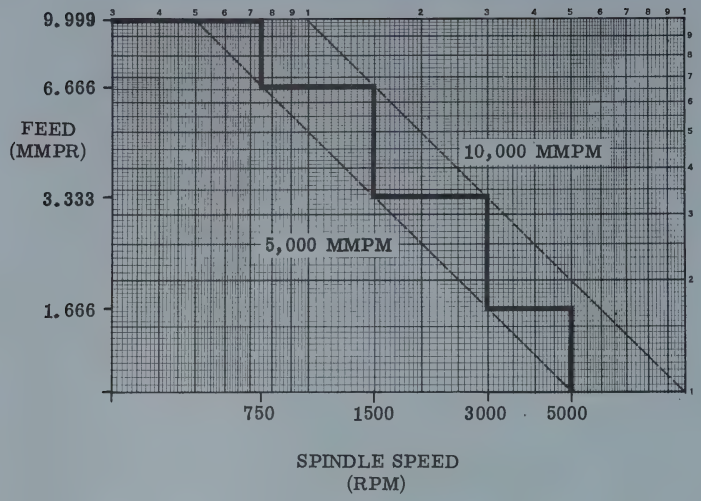


Figure 8.
MAX PROGRAMMABLE FEED (MMPR) VS SPINDLE SPEED
FOR CONTROL WITH 50-100% SPINDLE SPEED OVERRIDE

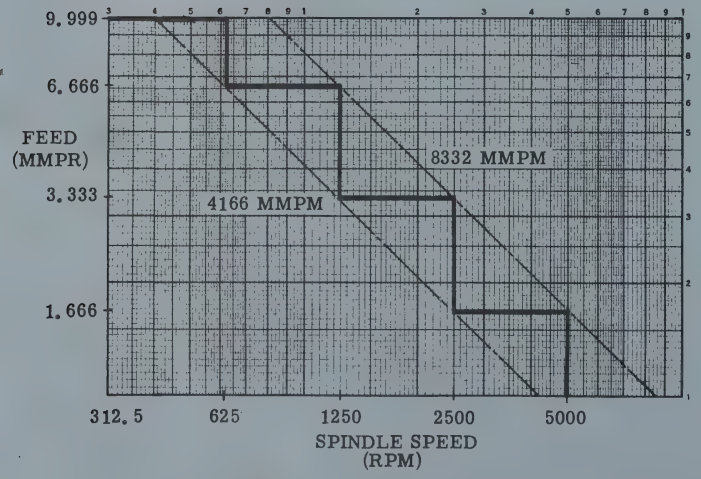
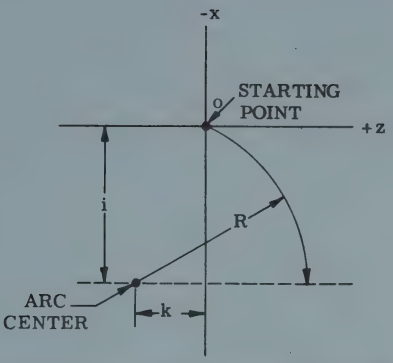


Figure 9.
MAX PROGRAMMABLE FEED (MMPR) VS 100% SPINDLE SPEED
FOR CONTROL WITH 50-120% SPINDLE SPEED OVERRIDE



When circular interpolation is used, if the corresponding value of i or k for the arc center offset is zero, it need not be programmed.

ARC-CENTER OFFSET PROGRAMMING EXAMPLES

Programming examples for arc-center offset are given below. The first two examples are for incremental data programming.

EXAMPLE #1

In the following example of millimeters-per-minute arc programming, let us assume that:

Command resolution = 0.001mm

Radius (R) = 5mm

Departure in z direction = -5mm

Departure in x direction = -5mm

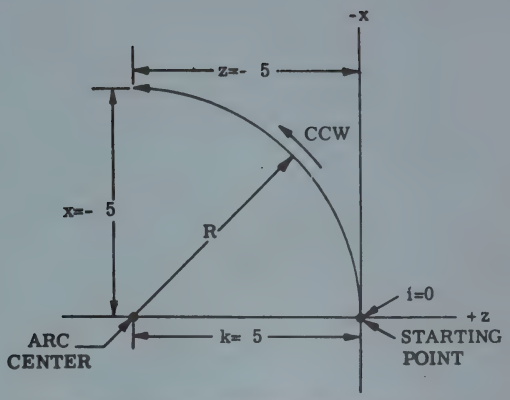
Offset (k) along z axis = 5mm

Offset (i) along x axis = 0mm

Feedrate desired = 150mmpm

Arc direction is counterclockwise by non-EIA definition which views the x-z plane tooling along the positive y axis. (EIA would require the view to be from the other side of the plane.)

For this example, then, g03 is used for the preparatory command.



To indicate the actual numbers involved and the location of their decimal points (decimal points can be programmed if desired), the block could be programmed as follows:

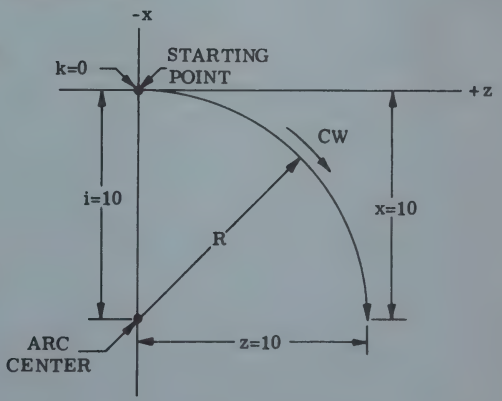
g03x-005.000z-005.000i000.000k005.000f0150.0 EOB

The actual program block, when omitting trailing zeroes, would be:

g03x-005z-005k005f015 EOB

If the decimal points are programmed, it is suggested that the trailing zeros be programmed for manuscript clarification. Note also that i is not programmed because it is equal to zero.

EXAMPLE #2



Let us assume that the dimensions and directions are changed in example 1; the dimensions are increased (that is, x = +10.0", z = +10.0" and R = 10.0"), but the desired feed rate is 100 ipm and a clockwise arc is desired.

The program for this example is:

g02x1z1i1f1EOB

If the Omit Leading Zero Machine Setup Data selection had been made, the program would be:

g2x100000z100000i100000f10000EOB

In this example the k is not programmed because it is zero.

EXAMPLE 3

This is an example of arc programming in absolute data input (g90). The arc-center is on the origin (x0, z0) or program zero. Arc direction is counter-clockwise. The g03 preparatory command is used.

Assuming that:

Command resolution = 0.001

Radius = 50mm

Feed Rate desired = 500 mmpm

The center os the tool is positioned at x000.000mm, z+050.000mm

Departure in the z direction is from z = +50mm to z = 0

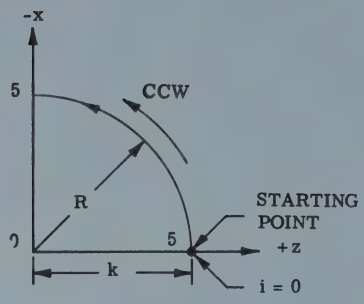
Therefore, the programmed z word is z = 0

Departure in the x direction is from x = 0 to x = -50mm

Therefore, the programmed x word is -05mm

Offset (k) along z axis = 50mm

Offset (i) along x axis = 0



The program is:

n0001g03x-05z0k05f05EOB

Note: In the n0001 block z0 is programmed: if this dimension word is not programmed, the Control assumes that no movement in z is to occur. Trailing zeros have been omitted.

EXAMPLE 4

Arc programming in Absolute Data Input (g90) mode is desired without a full quadrant move. The arc radius is not on the origin. Arc direction is counter-clockwise.

The g03 preparatory command is used.

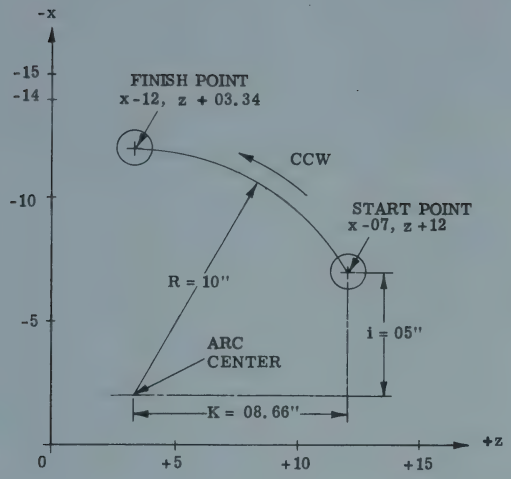
Assume that:

F = 50.00 ipm

Command resolution = 0.0001

Radius = 5.0"

The center of the tool is positioned at x-07.0000", z +12.0000"



The end point of the arc is x-12.0000" and z+03.3400" from program absolute zero. The arc-center offsets must be programmed as an incremental distance from the center of the arc to the start point.

k = 08.6666"

i = 05.0000"

The x and z finish points must be programmed as absolute dimensions from program absolute zero.

The program is:

n0001g03x-12z0334i05k086666f05EOB

SPINDLE SPEED COMMANDS

Program spindle speed with letter address "s" and 2, 3, or 4 digits. With Machine Setup Data, the user has the selection of an s word of 2, 3 or 4-digit length. The choice of digit group is made at the time of installation.

s2-Program s and 2 digits (00 to 99).

s3-Program s and 3 digits (000 to 999).

s4-Program s and 4 digits (0000 to 9999).

If a new spindle speed is programmed without a change in gear range, a dwell period should be programmed to allow for spindle speed stabilization.

Dwell periods should be selected which are compatible with proper machine operation.

DIGITAL-TO-ANALOG SPINDLE OUTPUT

The Spindle Speed Control with a digital-to-analog converter is supplied for use with 2, 3, or 4 digit s words. One hundred or one thousand speed points are interpreted as proportional voltage outputs. These are decoded from the 2 or 3 (by Machine Setup Data) least significant digits of the s data. Direction and speed range are determined by m codes or with an additional s digit.

The top-speed signal output is approximately ±8.0 volts DC. Machine Setup Data is used to provide the following range of output voltage:

0 to ±8VDC approximately

Used where the output polarity determines the spindle rotational direction. The polarity is determined by the associated m function (m03 or m04) programmed. See Programming Spindle Direction and Stop Codes, below.

0 to + 8VDC approximately

0 to - 8VDC approximately

Programmed speeds are expressed as a percent of the top speed for that range. Direct RPM programming is available as an option and the programming is described in Section 5 of this chapter. Decoding, storage, and relay-driver outputs are provided for 2 direction signals. A Stop Code signal is represented by the absence of direction signals. Output-driver outputs for m or s codes may be used by the customer to decode speed ranges.

PROGRAMMING SPINDLE SPEED DIGITAL-TO-ANALOG

For s2 programming, up to 99 speeds may be programmed with speeds expressed as a percent of the top speed for a given range. With s3, the last 2 digits are used for spindle speed command and the first digit is used for gear range or all 3 digits may be used for up to 999 speed selections. For s4 the 3 least significant digits are used for up to 999 speed selections. The choice of digit group is made by Machine Setup Data selection. For s4 programming, the first digit may be used to select the speed range by means of output-driver outputs. (See s code BCD output-driver output on this page).

PROGRAMMING SPINDLE DIRECTION AND STOP CODES DIGITAL-TO-ANALOG

M functions used for spindle direction and for Stop codes follow:

m03 clockwise m04 counterclockwise	(Digital-to-analog converter and output driver output signal)
m05 spindle stop	Digital-to-analog converter blanking and no output driver output signal.

NOTE:

1. A Control clear condition assumes a spindle stopped (m05) condition.

2. The spindle may be started (m05 cleared) by programming a block of data with a new spindle command (s code) along with an appropriate direction command (m03 or m04).

3. An m00, m01 (if selected), m02, or m30 command also causes a spindle stopped condition.

OPERATOR'S SPINDLE SPEED DEVICE (Optional)

A 50-to-100% Spindle Speed Override potentiometer is supplied on the Operator's Control Panel. This allows the operator to adjust the actual spindle speed to a rate which is less than the programmed speed.

A second option provides a 50-to-120% spindle speed override.

S CODE BCD OUTPUT DRIVER OUTPUT (OPTIONAL)

Part of the Standard Machine Interface option contains full BCD output driver outputs for up to 3 s digits. With a 4-digit s code, only the 3 most significant digits are output. Static logic and output driver outputs (4 per decade) are provided in binary coded decimal. All output driver outputs are rated for a maximum of 250 ma and 25 volts DC.

In addition to the binary coded decimal (BCD) output driver outputs, an s strobe signal is brought out as an output driver output, which produces a momentary signal whenever an s command is read and transferred to active. The signal starts approximately 48 milliseconds after completion of the previous block and lasts for 48 milliseconds. These times may be changed by Machine Setup Data.

TURRET AND TOOL OFFSET SELECTION

Standard Tool Offsets

Program the turret code and tool offset with the letter address "t" and 4 digits. The first two digits are used for tool number and the last two are used for tool offset number.

The 1050T Control provides a total of 32 pairs of tool offsets for the x and z axes. These offset pairs may be assigned to any turret position (tool number).

Offset size is selected by Machine Setup Data to be 3, 4, 5 or 6 digits. The maximum offsets are ±0999"/.999mm, ±.9999"/9.999mm, ±9.9999"/99.999mm, ±99.9999"/999.999mm. The offset is initiated when the t information becomes active. Dimension or dwell information can be but is not required to be programmed in a block calling for a tool offset. The tool offset command would be executed before the dimension or dwell command.

The active tool offset is cleared on any zero cycle (grid, set or reference.) A T0 command should be inserted at the end of a program to cancel the tool offset.

T CODE BCD OUTPUT DRIVER OUTPUT (Optional)

Part of the Standard Machine Interface option contains BCD output driver outputs for tool numbers 0 thru 99. The tool number is the 2 most significant digits of the t code. Static logic and output driver outputs are provided in binary coded decimal. All output driver outputs are rated for a maximum of 250 ma and 25 volts DC.

In addition to the binary BCD output driver outputs, a t strobe signal is brought out as an output driver output, which produces a momentary signal whenever a t command other than t00XX is read and transferred to active. The signal starts approximately 48 milliseconds after completion of the previous block and lasts for 48 milliseconds. These times may be changed by Machine Setup Data.

TOOL OFFSETS COMBINED WITH COMMAND (CWC) (Optional)

This option permits the x and z tool offset values to be combined algebraically with the x and z departure commands into one vectorial departure at the programmed rate.

The offset occurs when the block containing the t code is transferred to active and combines algebraically with any linear departure programmed in the block at the desired feedrate. If the offset is called for in a block with an arc programmed, the x and z tool offset moves take place after the arc is completed. If the offset is called for in a block with no other departures, the x and z tool offset moves take place immediately.

If an offset is active and another offset or no offset (t00) is called for, the resulting tool offset values are equal to the difference between the active offset and the new offset values.

MULTIPLE MANUAL FEED OVERRIDE (MFO)/ MULTIPLE SPINDLE SPEED OVERRIDE (SSO) SELECTED BY T WORD (OPTIONS)

These options permit the operator to establish different MFO/SSO settings for up to 16 tool offset pairs. Sixteen adjustable miniature potentiometers are used to make the MFO/SSO settings. The range of settings is 0 to 120% of the programmed value for MFO and 50 to 100% of the programmed value for SSO. Any of three combinations of MFO and SSO may be used as shown below:

MFO	SSO
16	0
16	16
8	8

The main MFO/SSO is active for the Test or Manual mode and for TXX00 and TXX17 and greater. The main MFO/SSO is not active for TXX01 through TXX16.

MISCELLANEOUS COMMANDS

Program each miscellaneous command with letter address "m" and 2 digits. Only 1 miscellaneous command may be included in a block of data. A total of 100 miscellaneous commands is provided (m00 through m99). The names and functions of the m commands are outlined in the following chart:

Table 3.
MISCELLANEOUS COMMANDS

CODE	NAME	FUNCTION
m00	Program Stop	Initiates a programmed stop. May be used to indicate a stopping point necessary for a tool change or other similar operation. When the command is read, the tape reader stops after the block has been read. After the completion of all commands in that block stops the controlled motions and turns off the Cycle Start light. The PROGRAM STOP message is displayed and remains until either Cycle Start, Tape Forward, or Tape Rewind is initiated or the Display mode is changed.
m01	Optional Stop	Performs the same functions as m00 if the Optional Stop pushbutton has previously been depressed, and the Optional Stop indicator light is on. The Control stops on the next m01 command. (To resume operation, initiate Cycle Start, Tape Forward, or Tape Rewind.) If an m00, m02, or m30 is read prior to reading an m01, the Optional Stop indicator light turns off.
m02	End of Program	Performs the same functions as m00, except it does not display the program stop message. In addition: The END OF PROGRAM M02 message is displayed. After executing other commands in the block, a "clear operation" is performed, which clears all active part program commands except tool offsets. Cancels parity check.
m03	Spindle Clockwise	Starts the spindle rotation in the direction to advance a right-handed screw (twist drill at boring position) into the rotating workpiece.
m04	Spindle Counterclockwise	Reverse of clockwise.
m05	Spindle Stop	Stops the spindle and clears the active s command.
m06 through m29	Unassigned	

(Continued)

Table 3.
Continued

CODE	NAME	FUNCTION
m30	End-of-Tape	Performs the same function as m02 except displays END OF PROGRAM MSO. Causes the tape to rewind to the Stop Code.
m31 through m59	Unassigned	
m60 (position offset option)	X and Z Axes Simultaneous Reference Zero.	Causes x and z axes to execute a simultaneous Reference Zero and preset the position registers with the dimensions stored in tool offset number 98. See Position Offsets, Section 8.
m61 (position offset option)	X Axis Reference Zero.	Same as m60 except for x axis only.
m62 (position offset option)	Z axis Reference Zero.	Same as m60 except for z axis only.
m63 through m79	Unassigned.	
m80 (CSS option)	CSS override on	Inhibits spindle speed change in CSS mode.
m81 (CSS option)	CSS override off	Permits spindle speed change in CSS mode.
m82 through m99	Unassigned	

Two output driver signals, which last approximately 48 milliseconds, are provided for customer use:

1. m00, m02, or m30 OD
2. m01 OD

The OD signals above start 48 milliseconds after completion of the block. The delay and signal length may be changed by Machine Setup Data.

M Code BCD Output Driver Output (Optional)

Part of the Standard Machine Interface option contains BCD output driver outputs for 2 full digits of m code data.

Static logic and output driver outputs are provided in BCD. All output driver outputs are rated for a maximum of 250 ma and 25 volts DC.

In addition to the BCD output driver outputs, an m strobe signal is brought out as an output driver output, which produces a momentary signal whenever an m command is read and transferred to active.

The signal starts approximately 48 milliseconds after completion of the previous block and lasts for 48 milliseconds. These times may be changed by Machine Setup Data.

SECTION 4
THREADCUTTING

A resolver used as a tachometer driven by the machine spindle generates a specific number of digital pulses per spindle revolution by means of a spindle pulse-generator circuit. These pulses are processed by the Control and fed to the servos of the machine. Therefore, the rate of travel of the machine motions is directly related to the rpm of the machine spindle. When the lead and the g33, g34 or g35 (preparatory command) are programmed, the machine will produce threads of any lead, from 0.00001 inch/rev. to 9.99999 inches/rev. (00.0001 to 99.9999 mm/rev.) for a six-digit system. For a seven-digit system (Machine Setup Data Selectable) the leads are 0.000001 inch/rev. to 9.99999 inches/rev. (00.00001 to 99.99999 mm/rev.) Threads can be cut linear g33, on a taper g33 (if departures are programmed for two axes simultaneously) or variable lead for non-taper threads only.

Table 4.
LEAD COMMANDS FOR THREADCUTTING (Figures 10-13, pages 4-37)

Speed Range	Thread Lead i, k Register	Maximum Length x or z Register	Spindle Speed revolutions-per-minute
6-digit Control	9.99999 in. 99.9999 mm	99.9999 in. 999.999 mm	5000
7-digit Control	9.999999 in. 99.99999 mm	999.9999 in. 9999.999 mm	5000

NOTES:

1. The top spindle speed is an absolute limit. In addition, the ipm limitation for a machine axis may further limit the rpm for a given lead command (rpm maximum = ipm max/lead). Normal programming requires derating (95% for example) to allow for spindle speed variation.

2. Refer to Figures 10-13, pages 34-37, for the maximum programmable lead vs spindle speed.

Preparing for a Threadcutting Operation

Prior to performing a threadcutting operation, the spindle speed must be stabilized. This is necessary because the spindle and the motion are electrically connected. Therefore, any variation in spindle speed will also cause a variation in servo speed. Also, since the servo lag depends upon the speed of movement, all threadcutting cuts on a given thread must be made at the same speed when the thread is being retraced. The slides must also be up to the required cutting speed prior to the tool entering the workpiece.

Programming Requirements for Threadcutting

Program the spindle speed for a threadcutting operation in the block of data which precedes the block calling for threadcutting. Be sure to allow enough time for the spindle speed to stabilize before the Control enters the Threadcutting mode. For example, when you are preparing the Control to enter a Threadcutting mode, program the axes away from the workpiece in order to allow time for the turret to index and the spindle to change.

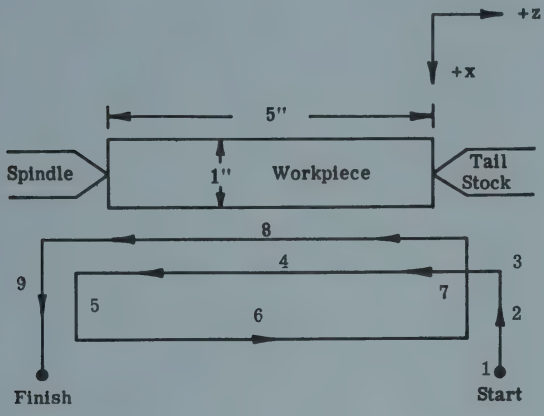
EXAMPLES OF THREADCUTTING PROGRAMS

Four examples for linear or taper threads follow.

Example No. 1 - Constant Lead on a Shaft of Uniform Diameter

For this example, let us assume that the workpiece shown in the diagram on the following page has been machined previously by ordinary cutting means and that it now is ready to have threads with a 2mm lead cut along its entire length.

This example involves synchronization, the making of a threading cut in response to block 4, the return to a specified point at 1000 mmpm, resynchronization, and the making of another threading cut on the same thread in response to block 8.



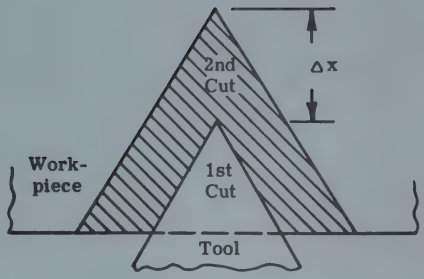
The program necessary to perform the operation shown in the figure above is as follows:

1. g94
2. g01x-010834f1s05
3. g04x05
4. g33z-07k002
5. g01x01
6. z07
7. x-0107
8. g33z-07k002
9. g01x01

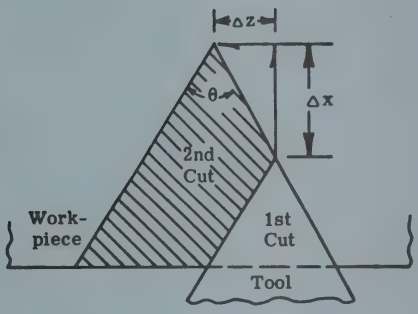
Example No. 2 - Compound Feed Compensation

Often threads are cut on a lathe using a compound feed which is set at 1/2 the thread angle. In Example No. 1 a plunge cut is used, and no correction is made to cut on a single side of the tool that the compound feed provides (Diagram A, below). To obtain improved cutting, program a correction in the z axis prior to the g33 command. As illustrated in diagram B, below, when the depth of the new cut is chosen, the z axis correction ($\triangle z$) may be computed by:

$$\triangle z = \triangle x \tan \frac{\theta}{2} \quad \triangle x = \text{depth of cut.}$$



(A) PLUNGE FEED



(B) COMPOUND FEED

for $\theta = 60°$ this becomes:

$$\triangle z = \triangle x \tan 30° = 0.57735 \triangle x$$

The tool moves into the shaded area for the next cut.

If compound-feed compensation had been used in Example No. 1, the program would have to be altered as follows:

From blocks 5 and 7, it can be seen that the depth of the second cut, $\triangle x$, is 10.7-10. = 0.7 mm.

Thus,

z = 0.57735 x 0.7 = 0.40414.

This correction would then be made in block 6, by subtracting 0.40414 from 70mm (70.00000 - 00.40414 = 69.59586). Block 6 now becomes z69596.

Example No. 3 - Face Threads

By programming the lead with the letter address "i", it is possible to cut threads in the face of a workpiece. In this case, the threadcutting tool must be properly oriented to make threads on the end of the workpiece. For this operation, the x axis is programmed in the same manner as that used for the z axis. In addition, compound feed compensation can also be made in a manner similar to that described in Example No. 2, except that the x and z axes must be interchanged. In order to calculate the departures for a tapered threading operation, co-tangent information is necessary if the x displacement is not known. Angle θ is the angle of the tool path with respect to the z axis.

In the diagram below, a facing thread of 10 threads-per-inch is desired. Blocks 1 through 8 are programmed as they were in Example No. 1 except that the Threadcutting command is for the x axis rather than the z axis. For block 9, the departure lead for the x axis is programmed directly into the x and i sections. The z and k commands are determined as follows:

z = x cot θ	k = i cot θ
z = 5 cot 60°	k = 0.1 cot 60°
z = 2.88675 inches	k = 0.057735

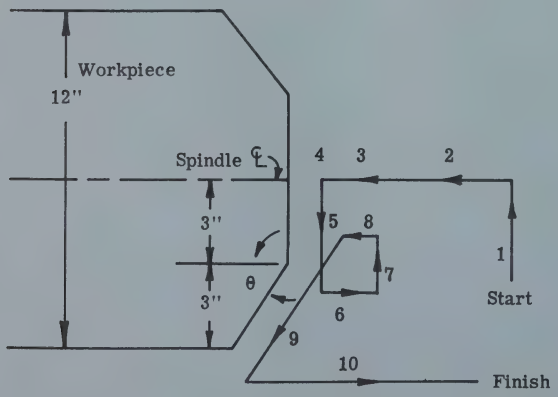
Program

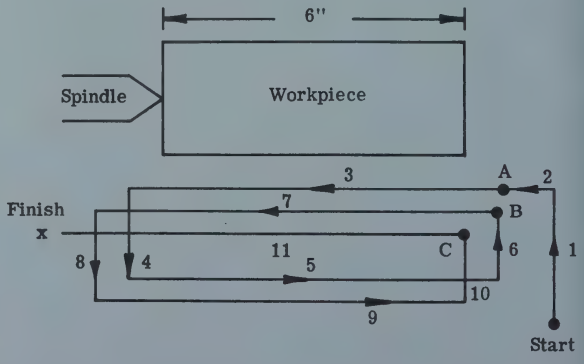
1. g01x-03f1
2. z-03
3. z-000552f01
4. g04x05
5. g33x04i01
6. g01z01f1
7. x-015
8. z-007113
9. g33x05z-028868i01 k005774
10. g01z056533

Example No. 4 - Multiple Threads

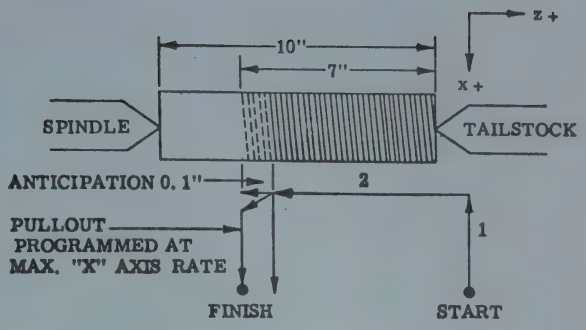
As soon as a threadcutting command (g33) is received by the command storage of the Control, the Control waits in order to engage the motions at the proper angular position of the spindle. As soon as the spindle reaches this position, the x and z drives are instantly "engaged" in a manner similar to that used by the operator on a manual machine when he receives a correct indication on a threading dial. It then becomes evident that to exactly retrace a prior thread, the tool must be in exactly the same position, or in a position exactly one screw-pitch different when the threadcutting command is again received. This is a simple matter to program, since the first position is accurately known.

If more than one thread is to be cut on a single shaft, the starting point for each thread must be displaced a precise amount from the thread. In the following diagram, it is desired to cut a three-thread screw with 12 threads per inch. Note here that the lead is not 1/12, but 3/12 threads per inch.





1. g01x-0105f00
2. z01 ('A' Sync Point)
3. g33z-08k025
4. g01x01
5. z079167
6. x-01 ('B' Sync Point)
7. g33z-08k025
8. g01x01
9. z079167
10. x-01 ('C' Sync Point)
11. g33z-08k025



Movement to a new sync point is accomplished in block 5 and 6. In block 5 the new sync point (B) is calculated by dividing the lead (0.25 inch-per-thread) by the number of threads (3) and positioning the tool this amount closer to the work (point B in the diagram) when g33 is programmed. Repeat this procedure for point C.

ANTICIPATED PULLOUT PROGRAMMING

Pullout is the rapid removal of a cutting tool from the workpiece before the threadcutting operation is complete or at the completion of the threadcutting operation. Pullout programming is used to prevent a ringed or damaged thread resulting from no tool motion while the spindle is running.

Since the 1050T Control has buffer storage, pullout is accomplished by programming. There are no special g codes or options required to accomplish pullout.

Pullout Anticipation Command

Anticipation is the distance from the end point of the z departure to the pullout point. Anticipation is accomplished by programming the z departure in 2 separate blocks. Because the second z block is in buffer while the first block is active, there is no pause between blocks.

Pullout Rate

The pullout rate may be programmed up to the maximum axis rate or to the maximums shown in Figures 8 and 9 (pages 35 and 36) whichever is the smallest.

Programming Example

Assume that the desired thread is as shown above.

The program necessary to perform the operation shown in the sketch above is as follows:

1. g01 x-01 f1 s05
2. g33 z-069 k0125
3. x01 z-001 i02 k0125

For the above example, assume the following:

Spindle speed	= 500 rpm
Thread lead	= 0.125 inch/revolution (8 threads per inch)
x Axis rate	= 100 ipm

In block 1, the x axis is moved from the starting point toward the workpiece at 100 ipm, and the spindle is brought up to speed (500 rpm).

In block 2, the z axis is programmed with a 6.9-inch departure which cuts the thread up to the beginning of the pullout. In this case, the anticipation chosen is 0.1000 inch.

In block 3, a g code is not necessary since g33 is a retained command (remains active until another g is programmed). The remaining portion of the thread, 0.1 inch, is programmed for z along with k0125, which is the same lead as in block 2 (0.125 in/rev). The x pullout is programmed so that x moves away from the work at the feed rate - 100 ipm.

$$\text{i Address} = \frac{\text{x rate (ipm)}}{\text{spindle speed (rpm)}}$$

$$= \frac{100 \text{ ipm}}{500 \text{ rpm}} = 1/5 = 0.2$$

The cutting tool will pull out at the angle produced by the i and k command programmed in block 3 neglecting the effect of the servo lag. The actual pullout rate is not affected by feedrate override.

The anticipation value is determined by the z departure in blocks 2 and 3. No "special" g codes are required in block 3.

RAPID ENTRY

The same programming technique used for pullout can be used for a rapid entry into the workpiece from a point off the workpiece. Rapid entry programming is used to minimize damaged threads at an entry point where thread depth cannot be established before part contact.

VARIABLE LEAD THREADCUTTING*

Variable leads which vary at a linear rate may be programmed. This allows an initial lead, a rate of change of lead, and a departure to be programmed. Depending on the g command, the lead increase or decreases through the departure. The maximum rate of change of lead is 0.99999 inches/rev/rev or 9.9999 mm/rev/rev.

DEPARTURE COMMANDS

Departure commands define the maximum length of thread which can be cut per block of tape information. The departures are similar to normal departures programmed when the Control is not in the Threadcutting mode.

VARIABLE LEAD COMMANDS

Variable lead threadcutting is programmable for one axis at a time. A g34 command causes a linear increase in lead. A g35 command causes a linear decrease in lead. In the Variable Lead Threadcutting mode, the f command gives the rate at which the lead increases or decreases.

Information concerning lead commands is given in Table 6 below.

Table 6.
LEAD COMMANDS FOR VARIABLE LEAD THREADCUTTING

Preparatory Command	Initial Lead i or k (maximum)	Rate of Change of Lead (Maximum)	MAX SPINDLE SPEED RPM
g34 (increasing lead) g35 (decreasing lead)	9.99999 in. (6 digit system) 99.9999 mm 9.999999 in. (7 digit system) 99.99999 mm	.99999 in/rev/rev 9.9999 mm/rev/rev	5000

PROGRAMMING VARIABLE LEAD

To program variable lead for a single axis, place the value of the starting lead for the axis chosen (x or z) in the appropriate register (i or k). Program the rate of change of lead per revolution with letter address f.

Linear increase or decrease in varying lead is the actual change of lead per revolution and not the change of lead per inch. To compute the variable lead command, use the following formula:

$$\triangle L = \frac{\text{(FINAL LEAD - INITIAL LEAD)}}{\text{NUMBER OF REVOLUTIONS}}$$

where $\triangle L$ = change in lead per revolution.

$\triangle L$ is minus for decreasing leads.

Since the screw length in inches is more readily known than the total number of revolutions and since the lead change is linear, the total number of revolutions may be computed in terms of screw length and average lead:

*Refer to page 28 "Threadcutting" for instructions in programming linear threadcutting and related techniques.

$$\text{No. of rev.} = \frac{\text{SCREW LENGTH}}{\frac{(\text{FINAL LEAD}) + (\text{INITIAL LEAD})}{2}}$$

The lead change can then be expressed as:

$$\triangle L = \frac{(\text{Final lead})^2 - (\text{Initial lead})^2}{\text{Screw Length x 2}}$$

The method by which lead change is converted into an f command is explained in the following paragraphs:

Precautions to be Observed When Programming Variable Lead

When increasing leads are being programmed, the lead number in the i or k register must not be allowed to go through zero. For example, if the lead is increasing, it must not increase to greater than the maximum lead in inches shown in the table under Lead Commands, i.e., if the maximum lead permitted is 9.99999 inch, then the lead must not be increased to a value greater than 9.99999 inch. If decreasing lead is programmed, the lead must not be allowed to go below zero.

Programming Example for Variable Lead Threads

Variable Lead on a Shaft of Uniform Diameter.

The following example involves cutting an increasing variable lead thread on the workpiece shown below.

In this example a variable lead thread is to be cut along the z dimension of the workpiece for a thread length of 5 inches. The initial lead is 0.1 inch and the final lead is 0.9 inch. Using this, calculate the variable lead command f, for block 3 as described in the paragraph entitled "Programming Variable Lead" above.

The f command calculation for this example is:

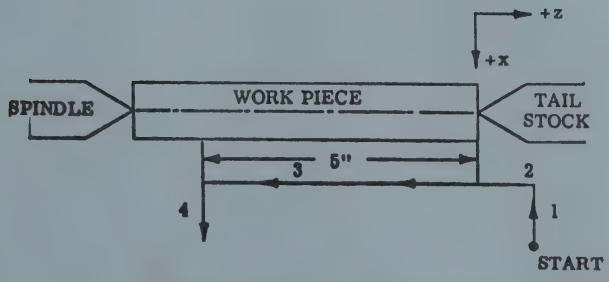
$$\triangle L = \frac{(\text{FINAL LEAD})^2 - (\text{INITIAL LEAD})^2}{\text{SCREW LENGTH x 2}}$$

$$= \frac{(0.9)^2 - (0.1)^2}{5.0 \times 2}$$

$$= 0.08$$

The f command becomes f08

Note that in the selection of the f command (f08), that after 10 revolutions of the spindle the instantaneous value of the threading lead is 0.9 inch/rev. The lead had not been allowed to exceed the maximum lead requirements defined in the paragraph entitled "Precautions to be Observed When Programming Variable Lead", above.



PROGRAM

1. g01 x-05 f00 s220
2. g01 z-02
3. g34 z-05 k01 f08
4. g01 x+05

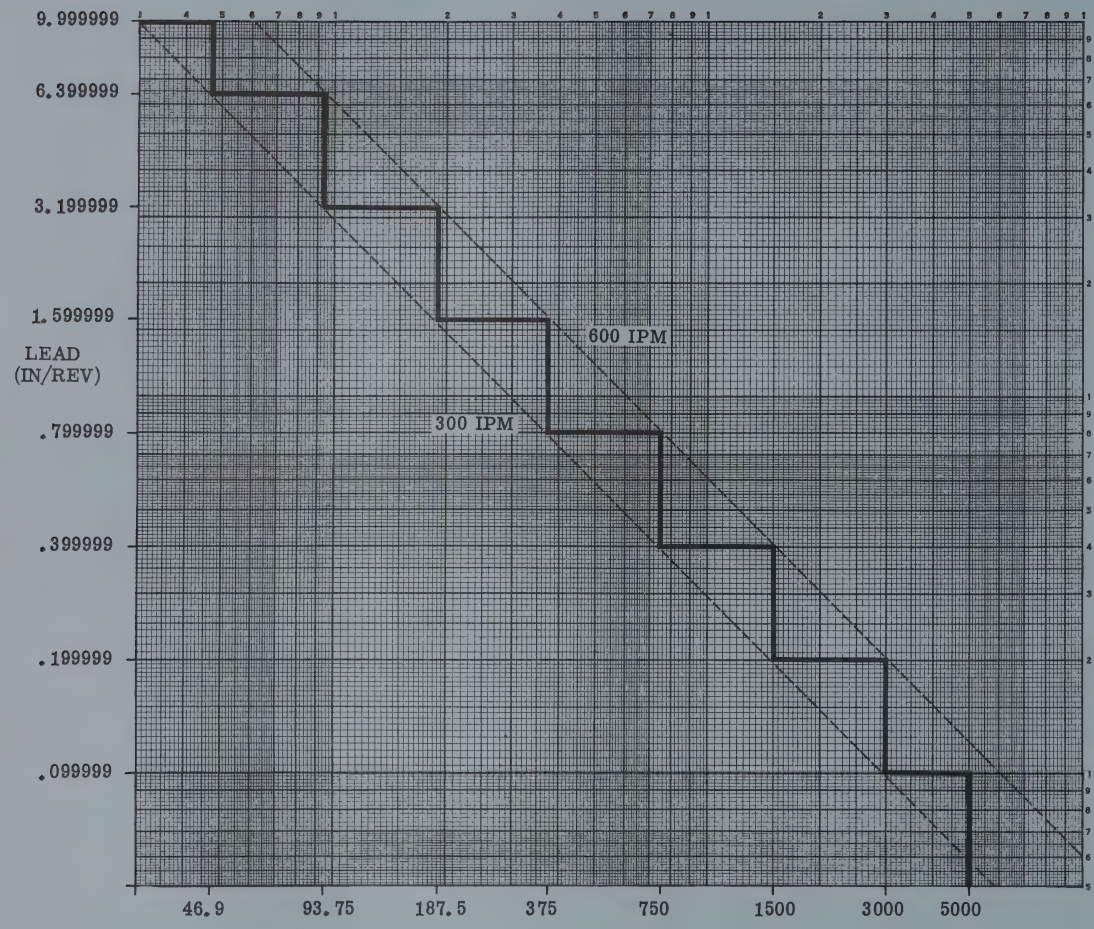


Figure 10.
INCH THREADCUTTING
MAXIMUM PROGRAMMABLE LEAD VS SPINDLE SPEED
FOR CONTROL WITH 50-100% SPINDLE SPEED OVERRIDE

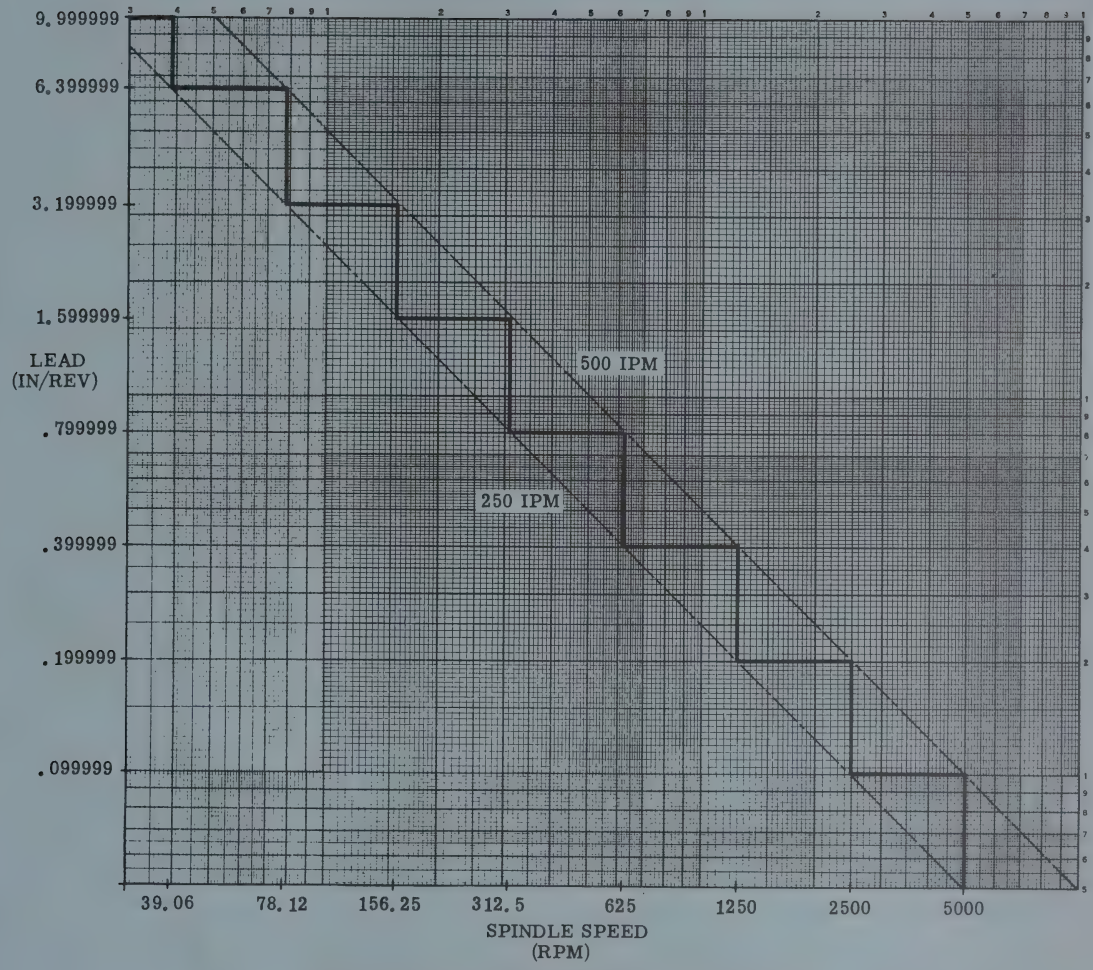


Figure 11.
INCH THREADCUTTING
MAX PROGRAMMABLE LEAD VS SPINDLE SPEED
FOR CONTROL WITH 50-120% SPINDLE SPEED OVERRIDE

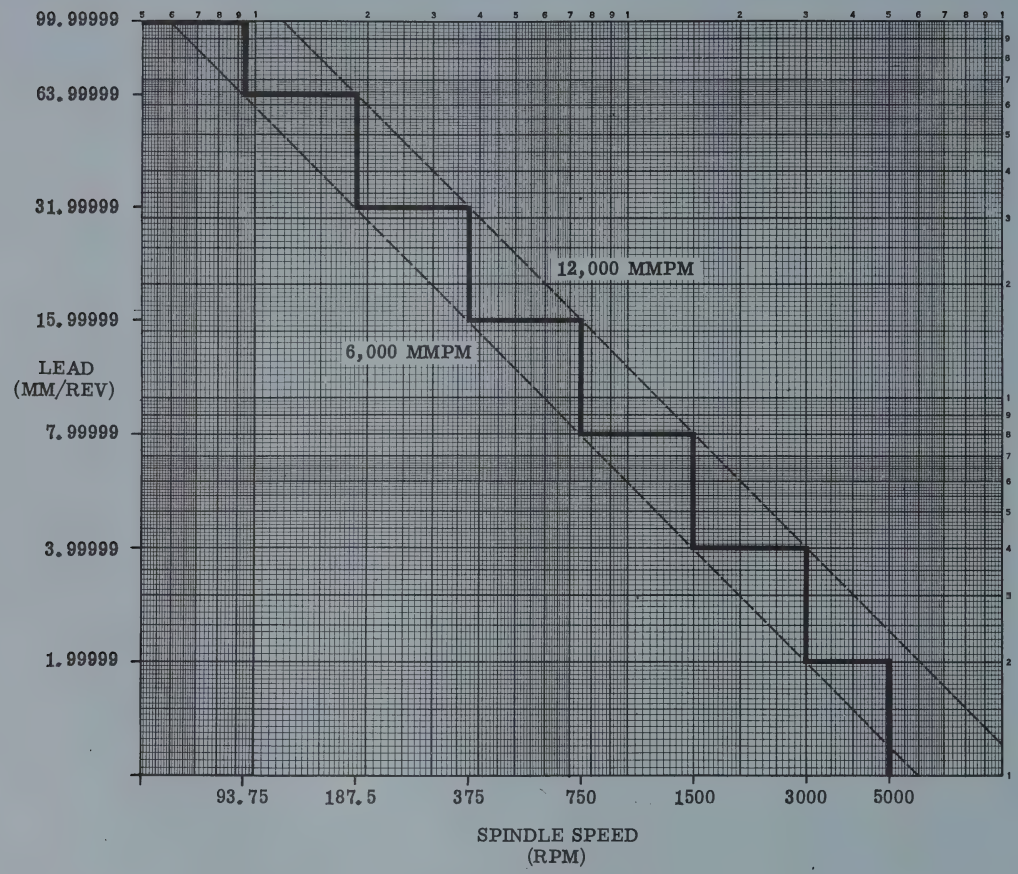


Figure 12.
METRIC THREADCUTTING
MAX. PROGRAMMABLE LEAD VS 100% SPINDLE SPEED
FOR CONTROLS WITH 50-100% SPINDLE SPEED OVERRIDE

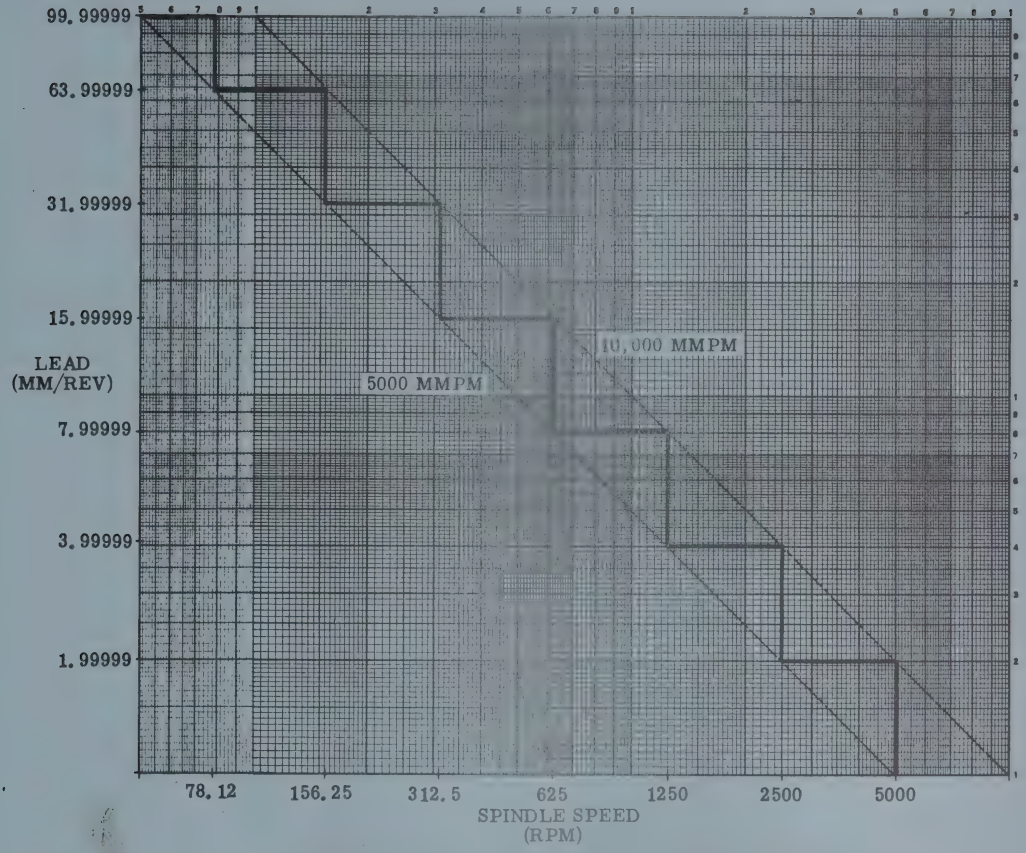


Figure 13.
METRIC THREADCUTTING
MAX PROGRAMMABLE LEAD VS 100% SPINDLE SPEED
FOR CONTROLS WITH 50-120% SPINDLE SPEED OVERRIDE

SECTION 5
CONSTANT SURFACE SPEED AND DIRECT RPM SPINDLE CONTROL (OPTION)

Constant Surface Speed

The Constant Surface Speed (CSS) option maintains a constant surface speed by controlling spindle speed so that it is inversely proportional to radius.

Constant Surface Speed is programmed with the s word in units called surface feet per minute in the Inch system and surface meters per minute in the Metric system. Programmable values for CSS may range from 0 to 9999 feet per minute and from 0 to 3000 meters per minute.

$$CSS = \frac{R \cdot rpm}{K}$$

$$rpm = \frac{K \cdot CSS}{R}$$

$$\text{where } K_{(Inch)} = \frac{12}{2\pi} \quad K_{(Metric)} = \frac{1000}{2\pi}$$

R is equal to the radius from the tool tip to the centerline of the spindle in inches or millimeters, and rpm is the speed of the spindle. The CSS Mode is selected by the g96 code.

In the CSS mode, a maximum limit spindle rpm is programmed with an s word and a g92 preparatory command. Having this constraint relieves the programmer of having to know the spindle rpm. Instead he programs the maximum limit governed by machine constraints.

Direct RPM Spindle Control

In the Direct rpm mode, the spindle speed is controlled directly by programming the s word (s4) directly in rpm (0000 to 5000 rpm) in 1-rpm increments. Alternately, the customer may select a low range rpm mode by factory software change, thus allowing the spindle speed to be controlled by programming the s command (S3.1) in 0.1-rpm increments (000.0 to 999.9 rpm). This software change also affects whether rpm for the CSS mode is calculated in 1 or 0.1 rpm increments. (Maximum rpm when the Control is in the CSS mode is 4900 rpm).

Direct rpm programming of the spindle is the assumed mode of operation upon power up or after any clear operation such as an m02 or an m30. This mode may also be selected by the g97 code.

Inputs And Outputs

The logic for controlling the spindle speed provides for 6 gear ranges. The customer is provided 6 inputs (to be used with normally-open contacts) to the Control which are used to change the gain of the spindle control to correspond to the selected spindle gear range.

The Control provides a DC voltage output that is proportional to the desired spindle motor speed in each gear range. The range of this voltage is from +8VDC for m03 to -8VDC for m04. Alternatively, the customer may select by Machine Setup Data, a voltage swing of 0 to +8VDC or 0 to -8VDC for both directions of rotation. Relay driver outputs for m03 and m04 are provided to permit the customer to control the direction of rotation of the spindle externally.

A spindle speed override is optionally provided to allow the operator to override the programmed spindle speed from 50 to 100% of the top speed in a given gear range. A 50 to 120% override option is also available.

Relay driver outputs for m codes are optionally provided for the customer to decode in order to select gear ranges.

PROGRAMMING

The following codes are used to program the CSS feature.

CODE	FUNCTION
g92	Identifies the s word as being the desired maximum revolutions per minute.
g96	Establishes the Constant Surface Speed mode. Cancels the Direct rpm mode and identifies the s word as being the desired constant surface speed. There should be an s code in the same block in order to enter the Constant Surface Speed mode.
g97*	Establishes the Direct rpm mode. Cancels the Constant Surface Speed mode and identifies the s word as being the desired spindle RPM. There should be an s code in the same block in order to enter the Direct rpm mode.
m80	Inhibits spindle speed change in the CSS mode. (Must not be active when m00 or m01 is programmed.)
m81*	Permits spindle speed change in the CSS mode.

*Assumed upon startup, clear, m02 or m30.

When changing modes with a g96 or g97, an s code should be programmed within the same block as the g code in order to establish the new mode. If no s code is programmed, the DC voltage output for spindle speed control is held constant until a new s code is programmed.

m80 and m81

An m80 command inhibits Spindle Speed Change in the CSS mode with an accompanying change in radius. In some operations, such as retracting the slide for a turret cycle and returning to the work, the resulting spindle speed changes are not only unnecessary but may be considered a nuisance. The m80 code is programmed to inhibit any spindle speed changes while the Control is acting on the block of data in which it is programmed and the blocks following. The radius register will continue to track the x axis while the m80 code is in effect so that the first calculation after the m81 code is programmed will result in the proper spindle speed. The m81 code cancels the m80 code. (Cancel means spindle speed change is permitted.) M80 must not be active when an m00 or m01 is programmed.

Maximum Spindle Limit RPM Preset For CSS

To select the maximum spindle RPM limit, program a g92 and then s0001 to s9999 in the same block. This RPM maximum is not effective in Direct rpm programming, but remains in storage for use in the Constant Surface Speed mode until the Control is cleared or m02 or m30, or until a new value is programmed. When entering the Constant Surface Speed mode, if a spindle speed maximum has not been programmed, cycle start turns off and a message NO MAX RPM is displayed. The software change previously mentioned determines whether S3.1 (.1-rpm increments) or S4 (1-rpm increments) is to be used.

SPINDLE SPEED MONITORING

The Spindle Speed Monitoring feature provides a means of guarding against spindle speeds in excess of those programmed under normal conditions. When a spindle overspeed is detected, an Emergency Stop is initiated and a SPINDLE OVERSPEED message is displayed.

A spindle overspeed is detected if either of the following conditions exist:

1. The average spindle speed for a 60-millisecond period exceeds by 137.5% or 150% (MSD selectable) the programmed speed for direct rpm programming or the maximum spindle limit rpm for CSS programming. A spindle overspeed is detected within 100 milliseconds after this condition occurs.

2. The spindle speed exceeds by 125% or 137.5% (MSD selectable) the programmed speed for direct rpm programming or the maximum spindle limit rpm for CSS programming, for 800 milliseconds ±50 milliseconds.

A tolerance band of 6 rpm must be added to the speeds in all of the above conditions.

When programming a lower speed than the last value, the new programmed speed is not used as a reference for this overspeed detection until after a delay of 6 seconds to allow for deceleration.

An input is provided so that the customer can disable the Spindle Speed Monitor by closing a contact when he is controlling the spindle speed by means other than programmed data. When switching back to programmed data control, the contact must be maintained long enough for the spindle to decelerate to the programmed speed.

Radius

In programming Constant Surface Speed, the distance from the tool tip to the spindle centerline must be known. This distance is stored in the r register and is continuously updated by all movements of the x axis except those caused by tool offsets or differential resolver offsets. The radius from the tool tip to the spindle centerline is automatically maintained except during a set, grid, or reference zero. When the ±r word is programmed, it must be equal to the radius from the tool tip to the centerline at the time r is programmed.

The sign to be programmed with the r code is opposite to that required to move the tool tip toward the spindle centerline using an incremental move. Thus in most cases r will be programmed as plus.

The radius (r) must be programmed in a g92 or g96 block.

EXAMPLE OF CSS PROGRAM

Spindle speeds resulting from the programmed Constant Surface Speed must be within the active headstock range.

The commanded spindle RPM will be zero for those values of RPM which are commanded or calculated to be less than 1 increment (1 or .1 rpm) and for calculated values of percent spindle motor speed which are less than 0.1% of the maximum spindle motor speed for the selected gear range.

The recommended programming order for establishing Constant Surface Speed follows.

n0001 g95 m03 - Establishes clockwise spindle direction and the ipr mode.

n0002 g92 r05 s1575 - Establishes the maximum spindle speed as 1575 rpm. Also establishes the starting position of the tool tip to be 5.0 inches from the part center line.

n0003 g96 f001 s1245 - Sets up Constant Surface Speed programming and establishes constant surface feet per minute at 1245 sfm. Establishes a feed rate of 0.001 ipr.

n0004 g04 x01 - (Optional) Dwells 1.0 seconds to allow the spindle to reach initial speed before entering the cut.

n0005 g01 x-03 -Commands the tool toward the part center line a distance of 3.0 inches.

n0006 g97 s2222 - Cancels the Constant Surface Speed mode and establishes a spindle speed of 2222 rpm.

NOTE:

1. Do not program a spindle range change and a spindle speed change in the same block of data. This could cause the spindle to overspeed due to differences in timing between the spindle gear change and the spindle speed control.

2. Neither CSS nor Direct RPM modes provide automatic spindle range changes. Therefore, the proper spindle range for the maximum and minimum radii involved must be selected prior to the CSS mode.

3. Provision is made to permit CSS facing operations to go "over center" so that the x and r commands change from + to -. The spindle RPM will not exceed the programmed maximum at or near zero radius.

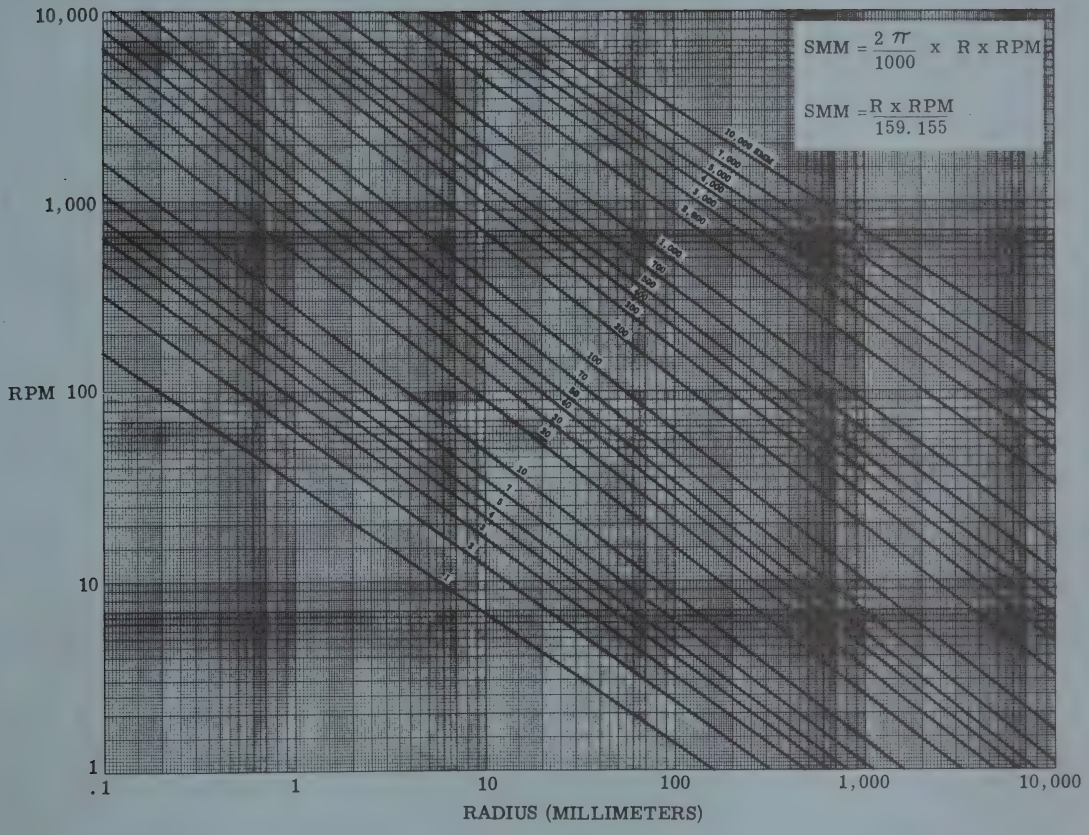


Figure 14.
SURFACE METERS PER MINUTE

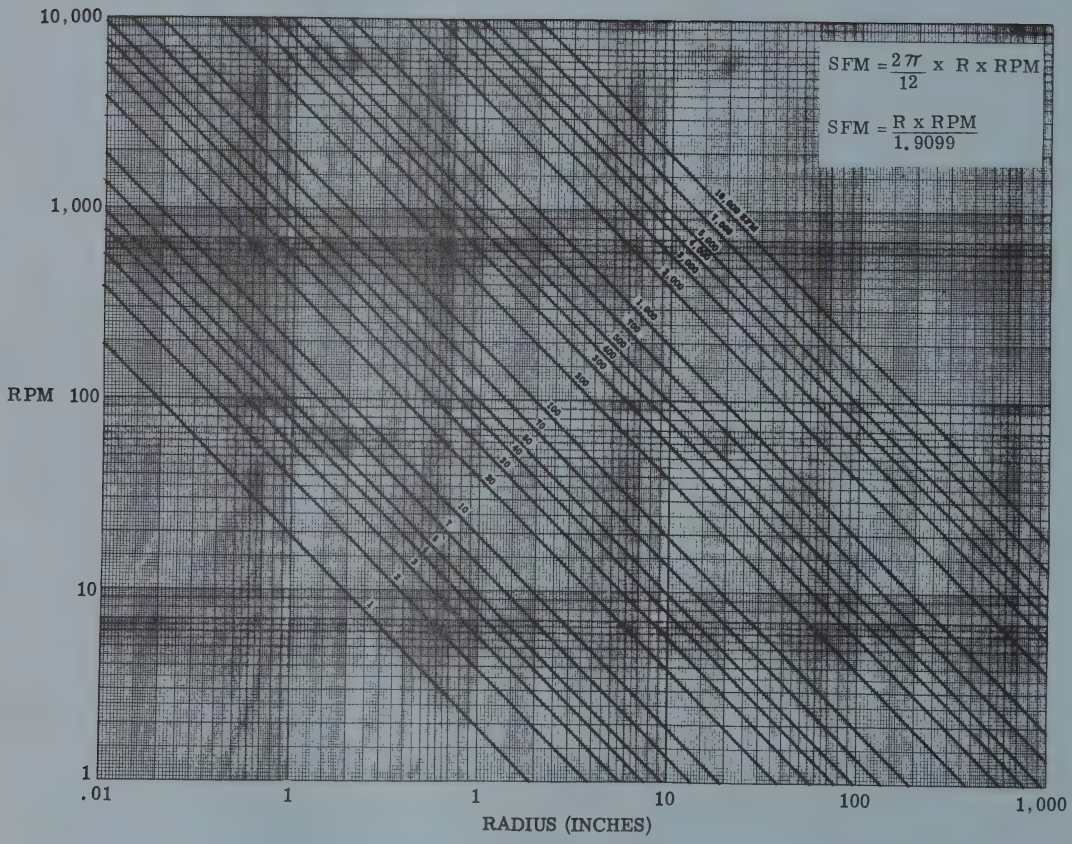


Figure 15.
SURFACE FEET PER MINUTE

SECTION 6
SUBROUTINES (OPTION)

The Subroutine Option is described at the end of this chapter in GEK-36091.

SECTION 7
PROGRAM STORAGE AND EDIT (OPTIONS)

The Program Storage option is an expandable option offering the ability to transfer up to 10 part programs from tape into memory and to operate therefrom. This capability may be expanded by adding additional memory, editing capability, and a punch interface so that corrected tapes may be created for permanent storage. In the paragraphs which follow a brief description of these options and their operating characteristics are given.

PART PROGRAM STORAGE (OPTION)

Part programs are stored in the Control memory starting at the location immediately following the executive software. The total part program storage capacity consists of the memory for part program storage plus any memory that may be left over after memory requirements for the basic Control and options are filled.

The maximum Control memory is 65K words. For example, if the executive tape, (basic software plus options) were 20K, then an additional 45K words (90,000 characters or 750 feet of tape) could be added for part program storage.

With this option, part programs may be stored in memory from punched tape. After a program has been stored, it may be executed any number of times without use of the tape reader. When operating from a stored program, the Tape Forward/Rewind switch, Tape Stop pushbutton, and Sequence Number Search controls operate on the stored program in a manner similar to their use with the tape reader when operating from punched tape.

Each program stored must be preceded and followed by a stop code. Each program in memory is identified by a Part Program ID. Part Program ID's are preceded by a dollar sign ($) in RS-358 or a percent sign (%) in RS-244. Some equipment may use the dollar sign ($) instead of the percent sign for the RS-244 code. See Figure 3, page 7 for the proper punch code. If the ID is not on the tape, it may be added at the time the program is stored, using the keyboard.

There is the capability of program identification for up to 10 part programs. Part Programs are identifiable by an alphanumeric program ID of up to 12 characters. If the part program is to be entered by tape, the part program ID should be punched in the tape immediately following the first EOB as illustrated below.

Stop Code	Stop Code
Tape Feed	
EOB	First EOB
$xxxxxxxxxxx	Program ID
EOB	2nd EOB

If the ID is not in the tape, the Control will display a message asking that the operator enters it through the keyboard.

The memory stores everything that is read from tape except delete codes (all holes) from the first EOB to the stop code at the end (which is ignored).

DISPLAYING THE INDEX OF STORED PROGRAMS

An index of all programs currently in storage is maintained in the Control memory. The Program Index Display mode displays part program ID, size of each program, and the available storage space.

If the 32-character single-line universal readout is being used, the Next pushbutton displays all part programs in storage; one line for each program number. If the optional 256-character universal readout is used, information of the first 8 part programs is displayed. Pressing the Next pushbutton displays the remaining 2 programs and the available storage space.

LOADING PART PROGRAMS FROM TAPE

To load a part program into memory, position the part program tape leader in the tape reader, select tape operation by placing the Program Source switch in the TAPE position, set the display switch in the PROGRAM INDEX position and then depress the Store Program pushbutton. The light in the pushbutton turns on, and the tape reader starts. The part program is stored in memory immediately following the last program previously stored, if any.

When tape reading begins, if the Control does not find a program ID at the beginning of the tape, reading stops and the message ENTER PROGRAM ID is displayed. The operator may then enter the program ID or he may abort the load by doing other operations.

If the program ID is unique, loading continues. If the ID matches one already in the index, the word DUPLICATE is displayed. At this point, the operator has the option of doing other operations or deleting the present program in storage and entering the new program.

The storage of visible or operator-readable characters placed on the leader for part program tape identification is not permitted.

Reading and storing continues from the Program ID until a stop code is encountered. Imbedded stop codes within the part program are not permitted.

If during the loading of a part program, the capacity of the memory is exceeded, the message MEMORY FULL is displayed on the universal readout, and the partially loaded program and its entry in the index are deleted.

If a reading error occurs, the message READ ERROR is displayed on the universal readout, and the partially loaded program and its entry in the index are deleted.

LOADING PART PROGRAMS FROM MDI

The Edit option is required if part programs are to be created and loaded by means of the MDI keyboard and Address Selector switch. Part program ID must be entered, manually as described above using a short part program tape which contains at least 1 block.

The new program is constructed in the Edit mode by adding new blocks as described under Part Program Edit, page 46.

DELETING PART PROGRAM FROM STORAGE

The operator has the capability of deleting individual part programs from the index and thus the memory by selecting the Program Index display mode, keying in the index number of the unwanted program and depressing the Delete Program pushbutton. The memory space vacated by the deleted program becomes part of the space available and any programs with higher index numbers will be reindexed to close the gaps. Programs may be deleted at any time, except if the program is the selected program, a message SELECTED PROGRAM is displayed and it is necessary to depress the Delete Program pushbutton a second time to delete the program.

SELECTING STORED PART PROGRAMS

When part programs have been stored in memory, it is possible to access a part program as follows:

1. Place the Display selector in the PROGRAM INDEX position.

2. Enter the Program Index (2-digit) number of the desired program using the MDI keyboard.

3. Depress the Select Program pushbutton.

4. The display now shows the selected program index and ID preceded by an asterisk.

5. Set the Program Source switch to the MEMORY position.

6. The Mode switch can now be set to SINGLE or AUTO and Cycle Start depressed to execute the program.

PART PROGRAM EDIT (OPTION)

The Part Program Edit option provides the capability for editing stored part programs. The MDI keyboard and other operator control devices are used with this feature. With the use of the Edit Retrace option the operator may run, modify, and rerun each block of the part program as necessary. The Edit option allows the operator to modify, add, or delete blocks from the stored part program with no restriction on the presence or order of sequence numbers. As the changes are made, the program is constantly updated in memory.

The Edit operation is described below:

To Modify a Part Program Block:

1. Select the Program as described under "Selecting Stored Part Programs", page 45.

2. Turn the Edit keyswitch to the EDIT position. (The Part Program Edit light turns on.)

3. Select the PROGRAM (EDIT) position on the Display switch (use Buffer (Edit) for the 32-character universal readout).

4. Put the desired block in buffer using sequence number search, the Tape Forward switch operated in Single mode, or Edit Retrace (option).

5. Set the mode switch to MDI.

6. Use the Letter Address switch and the number keyboard to update each word in the buffer block. The display shows the updated block as it is entered.

7. Set the Edit switch to MODIFY BLOCK.

8. Depress the Part Program Edit pushbutton (the Edit light turns off momentarily to indicate the edit function is being performed).

To delete a part program block:

1. Follow steps 1 thru 4 above which puts the desired (unwanted) block in buffer.

2. Set the Edit switch to DELETE BLOCK.

3. Depress the Part Program Edit pushbutton (the Edit light turns off momentarily to indicate that the edit function is being performed).

To Add a Part Program Block:

1. Follow steps 1 thru 4 under modify block to put the block in buffer which will precede the inserted block.

2. Set the Edit switch to ADD BLOCK.

3. Push the Next pushbutton to clear the buffer and make room for the inserted block.

4. Set the mode switch to MDI.

5. Use the Letter Address switch and the number keyboard to build the block to be inserted. The display shows the block as the data is entered.

6. Depress the Part Program Edit pushbutton (the Edit light turns off momentarily to indicate that the Edit function is being performed).

7. Repeat steps 3 thru 6 to add additional blocks.

To leave the Edit mode, turn the Edit keyswitch to the OFF position.

The display shows the part program block in buffer that is being edited with an arrow (>) along the left side.

TAPE PUNCH INTERFACE (OPTION)

A Tape Punch Interface is available as an option for use in conjunction with the Program Storage and Edit options. It provides the necessary electronic circuitry, plug receptacle, and software to accommodate a tape punch in accordance with EIA Standard RS-232C.

The customer supplied tape punch is mounted external to the Control enclosure.

This option provides the ability to obtain a corrected copy of a part program that has been edited and/or to convert a part program from RS-244 code to RS-358 code or vice versa.

The Punching sequence is described below:

1. Place the Display Selector in the PROGRAM INDEX position.

2. Enter the Program Index (2-digit) number of the desired program using the MDI keyboard.

3. Select the tape code (RS-244 or RS-358) for the desired punch output.

4. Set the Program Source switch to the MEMORY position.

5. If more than 12 inches of leader is desired, hold the Tape Feed switch on the punch long enough to generate a leader of the desired length.

6. Depress the Punch Program pushbutton. The pushbutton lights and punching continues until a stop code is read. A trailer of 12 inches is automatically added.

7. Additional trailer may be added to the tape by holding the Tape Feed switch on the punch long enough to generate the desired length.

8. If another copy of the same program is desired, repeat steps 5, 6, and 7.

For the RS-358 code, a carriage return code is supplied for every EOB (line feed). This allows the edited program to be listed in the same format as the original part program. A number of delete codes are supplied on the tape after every carriage return. The total number of delete codes inserted is selected by Machine Setup Data. These codes are necessary if a listing is to be made coincidental with punching.

When a part program is being punched, no other operations are permitted.

SECTION 8
POSITION OFFSETS (OPTION)

Position Offsets

The position offset option provides the part programmer with the ability to call for a reference zero of either or both axes under program control using m codes. When the reference zero limit switch is reached, the position registers are preset to the value stored in tool offset number 98. The dimension in t98 is stored by the machine tool operator using the same procedure as normal tool offsets.

The position offset option also provides the capability of accepting inputs from two additional limit switches per axis. One to force reference zero at traverse rate until a slow down point is reached, and the other to reverse the direction of the reference zero until the slide has moved to the correct side of the Reference Zero limit switch. An output is provided to indicate that the commanded axis has completed the reference zero cycle.

The position offsets establish the x axis part program reference zero at the center-line of the lathe chuck and the z axis part program reference zero at the face of the chuck. The dimensional data is entered as if it were a tool offset using t98 to designate it as being position offset data. This data is stored in the Control memory and is placed into the command position registers for the x and z axes after the machine has gone through its reference zero cycle and has synchronized on the grid point.

The MDI keyboard and Alphanumeric display are used for entering or changing the x and z position offsets. The position offset values are entered as offset t98 and follow the x and z word dimension formats.

NOTE

The dimensional data is not converted when switching from Inch to Metric or Metric to Inch and must be reentered the same as tool offsets.

The Zero pushbuttons light during the reference cycle whether initiated manually or by an m code.

The Reference Zero cycle can be initiated manually or it can be initiated by m codes programmed on the tape or input by MDI.

The following m functions apply:

m60	x and z simultaneous zeroing
m61	x zeroing only
m62	z zeroing only

The m code selected must be programmed in a block by itself. If data other than an n is in a block with m60/61/62 it is ignored and not displayed. When the reference zero is initiated, the reference zero feed rate equals the selected traverse rate. This rate is reduced to the standard reference zero feed rate when the customer's Slow Down limit switch which is normally closed is activated (input not maintained) and continues at this reduced rate until the Reference Zero limit switch is activated. Two inputs are provided for the customer's Slow Down limit switches: one for each axis. If the Slow Down limit switch is not used, the complete reference zero cycle is executed at the reference zero rate.

In the Automatic mode, the transfer of buffer data is inhibited until the reference zero and position offset cycle has been completed. The cycle start condition is maintained.

When the reference zero cycle is initiated, the active tool offset is reset and the BCD outputs for t are maintained.

A single output is supplied to the customer indicating that a reference zero cycle has been completed and the position offset data has been transferred to the position registers. This output is available as part of the BCD option.

If the reference zero cycle is initiated by an m60 or manually by pushing both the x and z Reference Zero pushbuttons, then the output signal is not made active until both axes have completed zeroing. This output remains energized until both axes are moved off their respective Reference Zero limit switches.

If the reference zero cycle is initiated by m61 or by manually pushing the x Reference Zero pushbutton only, the output is made active after the x axis has completed zeroing and remains active until the x axis is moved off its Reference Zero limit switch.

If the reference zero cycle is initiated by m62 or by manually pushing the z Reference Zero pushbutton only, then the same action as above takes place except it applies to the z axis.

One input per axis from the customer is provided that inverts, when active, the direction of the reference zero movement for that axis. This input indicates whether the axis is plus or minus with respect to the Reference Zero limit switch. The Control logic looks at this input anytime a reference zero cycle is initiated. This input is to be a normally-opened contact which when activated closes, indicating that the axis is on the opposite side of the Reference Zero limit switch and causing the selected axis reference zero movement to be inverted as long as the input is applied. This input must be maintained long enough for the axis to cross over to the correct side of the Reference Zero limit switch and also to pass the Slow Down limit switch. Once this occurs the normal reference zero cycle occurs (traverse rate to Slow Down limit switch, and then reference zero rate to Reference Zero limit switch).

The Position Offset option operates properly without the addition of the Slow Down switch (normally-closed contact) and the change of Reference Zero Direction switch (normally-opened contact) if the reference zero cycle is only called for while on the correct side of the Reference Zero switch in order to reference in the Machine Setup Data specified direction. If called for from the wrong side of the Reference Zero switch, the axis runs until it encounters an End-of-Travel limit switch. This is true because the omission of these switches is interpreted as both being opened, causing the machine to reference zero in the Machine Setup Data selected direction at the selected reference zero rate.

SECTION 9
DIAMETER PROGRAMMING (OPTION)

Diameter Programming allows the programmer to program x and r dimensions as diameter rather than radius. There are 2 MSD codes that determine the availability and programming to be used. L1116 allows Diameter Programming for x and r when absolute programming is active or when a g92 (preset position) is being entered.

L1119 used in conjunction with L1116 allows Diameter Programming to be used for all programmed moves for x and r.

DWELL

Dwell is unaffected by Diameter Programming and is still entered directly in seconds, or revolutions (MSD).

TOOL OFFSETS

L1116 causes all x tool offsets to be entered as Diameter. Z is unaffected. The display shows x as diameters. Odd digits are lost and must not be programmed.

The effective maximum tool offset for x is one-half what it is without diameter programming.

ABSOLUTE POSITION OFFSETS

The position offset for x which can be entered with MSD code L1502 is entered as a diameter.

INCREMENTAL JOG

Incremental Jog is unaffected by Diameter Programming; thus, selecting 10 mm and depressing the In or Out pushbutton causes x to move 10 mm. The position readout which is in diameter will show a change of 20 mm.

POSITION READOUT

The position readout for x and r is always diameter when Diameter Programming is active.

POSITION LAG

The position lag for x is always radius.

X DISTANCE TO GO

The x distance to go is always radius.

X POSITION OFFSETS

X position offsets are always entered as diameter.

DIAMETER INDICATION

The letters DIAM will appear at the right of the readout when g status is being displayed.

EXAMPLES OF DIAMETER PROGRAMMING

Some examples for Diameter Programming are shown below.

First, assume that the L1116 bit was set with MSD but the L1119 bit is cleared. This causes the x position to be displayed in diameter, x tool offset to be entered as diameter, x departures and r departures to be entered as diameter for g92. X departure is diameter for g90 moves and r is diameter for g96, distance to go will be radius as well as position lag. Dwell is still in seconds.

g90 x 100.000 (diameter) x PSN = 0
x distance to go = 50.000 (radius)

x 10.001 (diameter) x PSN = 100.000 (diameter)
x distance to go = -45.000 (radius)

The odd digit programmed above is illegal and will be lost.

g92 x 20.000 (diameter) R. 15,000 (diameter)
x PSN = 20.000 (diameter)
R PSN = 15.000 (diameter)

g04 x 5.000 (second) 5 second dwell

g91 x 100.000 (radius) x PSN = 0 at beginning
x distance to go = 100.000 (radius)

x PSN = 200.000 at end of above move (diameter)

For a desired offset of .1 on radius, enter x .2 (diameter). The maximum offset available for x with radius programming is twice the maximum available offset with diameter programming.

Radius Programming	Diameter Programming	Radius
9.999	9.9998	4.999

The zero position offset for x is also programmed as diameter.

Setting the L1119 bit as well as the L1116 bit causes x to be programmed as diameter for g91 as well as g90

g91 x 100.000 (diameter)
x distance to go = 50.000 (radius)

SECTION 10
DECIMAL POINT PROGRAMMING (OPTION)

Decimal Point Programming only applies to x, z, i, k, r, and f. These words still have the same number of digits to the left and right of the decimal point as established by the basic format selection in MSD for register sizing, (i.e. 2.4, 3.4). Until the decimal point is programmed, the digits enter to the left of the decimal point until the maximum number of digits that are allowed to the left of the decimal have been entered. The decimal point can be entered at any time, but it must be entered before any data to the right is entered. Any number of digits allowed by the format can then be entered to the right of the decimal point. When no digits are required to the right of the decimal point, it is not necessary to enter a decimal point.

Following are some examples of how data is used. Formats are 3.4 for x, z, i, k, r, and 3.2 for f.

Data from Tape or Keyboard	Data In Control
x 1	x 001.0000
x 12	x 012.0000
x 123	x 123.0000
x 1234 (too many digits to left)	x 123.0000
x 1.2	x 001.2000
z .1234	z 000.1234
i .001	i 000.0010
k 123.4567	k 123.4567
r .12345 (too many digits to right)	r 000.1234
f 123.45	f 123.45

Two of the above examples try to enter too many digits to the left or right of the decimal point. The Control will accept data up to the maximum number of allowable digits and discard any additional digits.

Non-decimal point words such as n, g, s, t, m, h, and l are still programmed using Omit Leading or Omit Trailing Zeros. Decimal points programmed with these words will be ignored.

SECTION 11
CANNED CYCLES

The Canned Cycle option greatly reduces the programming time for describing multi-pass operations required for single point threading or roughing.

The block of tape describing the cut move is programmed one time only, along with a canned cycle block (or blocks) to describe the number of passes to be made and the amount to increment the x and z axes at the beginning of each pass.

There are 4 situations where canned cycles may be applied:

UNIFORM DIAMETER SHAFTS (See Figures 6 and 17.)

1. Roughing cuts parallel to the z axis only.

2. Constant or variable lead threadcutting (using plunge or compound feeds) parallel to the z axis only.

TAPERED WORKPIECE (See Figures 18 and 19.)

3. Roughing cuts made with the x and z axes, but with entry to the work in the x axis only.

4. Constant lead threadcutting (using plunge or compound feeds) with cuts made with the x and z axes, but with entry to the work along the x axis only.

CANNED CYCLE PROGRAMMING FORMAT

Tool selection must be made and the spindle speed stabilized before the Control enters a canned cycle. The initial starting point of the tool must also be accomplished prior to entering a canned cycle. The initial starting position must be exactly 0.1000 inch or 2.000 mm from the workpiece surface as measured along the x axis.

FORMAT:

n0001 g01 ±x ±z f00

n0002 g83 ±xd ±zd h

n0003 g(01, 21, 33, 34, 35) ±x ±z i k f

n0004 g84 ±xd ±zd h

Block n0001

Block n0001 positions the tool to the initial starting point (0.1000 inch or 2.000 mm from the work surface measured along the x axis). This may be any type of move. The example shows a traverse move with the x and z axes. The spindle must be started and stabilized before the tool reaches the starting point.

Block n0002

Block n0002 contains a g83 command which activates a canned cycle. Xd and zd are the incremental distances that will be used to position the axes at the beginning of each pass. ±xd and ±zd values may be from 0 to 99.9999 inches or 0 to 999.999 mm. Only ±xd is required for plunge feeds or roughing, whereas both ±xd and ±zd dimensions are required for compound feed threadcutting.

IMPORTANT

±xd and ±zd must be programmed as INCREMENTAL distances even though the programmed departures (when not in Canned Cycle mode) may be ABSOLUTE dimensions. The signs programmed along with xd and zd are determined by the incremental direction desired from the canned cycle starting point. (See Figures 16 - 19.)

The letter h followed by 2 digits specifies the number of passes to be performed. Program h from 01 to 99. Do not program h00.

Block n0003

Block n0003 defines the type of cut to be made. The cut must be described in only one block during a canned cycle. Arcs may not be programmed during a canned cycle. The following g codes may be used for block n0003:

g01/g21 - Slope mode (for roughing cuts)

g33 - Constant lead threadcutting for tapered or uniform diameter workpiece

g34 - Increasing variable lead threadcutting for uniform diameter workpiece

g35 - Decreasing variable lead threadcutting for uniform diameter workpiece

If variable lead threadcutting is programmed, f must be programmed.

This block must contain a z departure.

The type and length of cut called for in block n0003 will be repeated h times as specified in block n0002. Each pass differs from the previous one by the incremental values of ±xd and ±zd programmed in block n0002. All non-cutting moves are at traverse speed. No machine motion takes place until both block n0002 and n0003 are read into active storage in the Control.

Block n0004

Block n0004 is an optional block that is programmed only if an additional pass or passes is to be made with a lesser cut depth from that specified in block n0002. The g84 specifies additional passes to be made (h times) with new incremental cut depths as programmed in block n0004. The incremental values for +xd and +zd must be equal to or less than those in block n0002. The cut will be made as specified in block n0003. It is not necessary to reprogram block n0003.

Any number of g84 blocks may be added, and when the last g84 pass is made, the canned cycle is automatically cancelled. If block n0004 is not programmed, the last g83 pass automatically cancels the canned cycle.

CANNED CYCLE PROGRAMMING NOTES

1. The cut must be described in one block only for a canned cycle. Arcs cannot be programmed for the canned cycles.

2. Canned cycles are intended to be used with entry and pullout moves off the work surface. All moves other than the actual cut are made at traverse rate, so canned cycle programming cannt be combined with "Rapid Entry/Pullout" programming.

3. If a tapered workpiece is to be cut, using canned cycles, the taper cannot be greater than 40^{0} from the z axis.

4. All entry and pullout moves are made in the x axis only. For most cases, this precludes the use of canned cycles for facing operations.

5. For a tapered workpiece, the total of zd increments for all passes must be small enough so that the return move can clear the work surface. (See Figure 19). Note that the return is always made to an imaginary line along the z axis which runs through the canned cycle starting point. It can be seen from Figure 17 that if the starting point is not correctly chosen, the return move would eventually hit the work surface. The selection of the starting point is a function of the value programmed for zd, the slope of the tapered work, and the number of passes to be made.

6. The zd sign must be programmed the same as the sign of the z departure for the cut move (block n0003, page 43).

7. The zd value programmed in a g84 block must be equal to or less than the zd value of the preceding g83 block, and each succeeding g84 block must have a zd value that is equal to or less than the previous zd. When another canned cycle is initiated by a new g83 block, zd may be any value from 0 to 99.9999 in. or 0 to 999.999 mm.

8. Do not program an "m" code in any of the canned cycle blocks. See "Application Comments" for canned cycles programming.

If m codes are desired, program them in a block with no other data following either block n0003 or n0004 in the preceding examples.

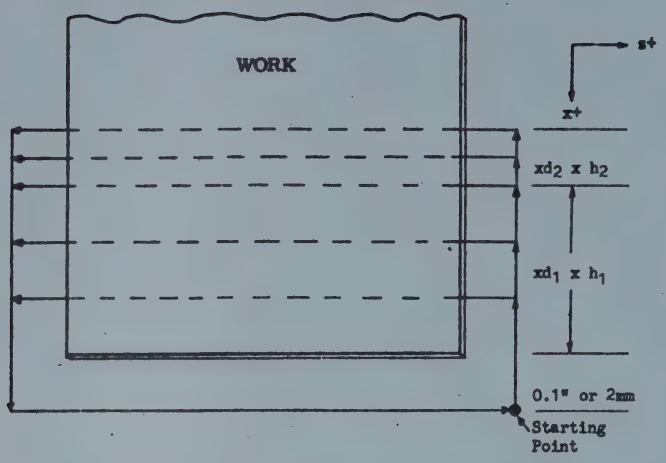


Figure 16
UNIFORM DIAMETER - PLUNGE FEED THREADING OR ROUGHING

n0001 g83 $\pm xd_1$ h_1

n0002 g01 (g33, g34, g35) $\pm z$ k f

n0003 g84 $\pm xd_2$ h_2

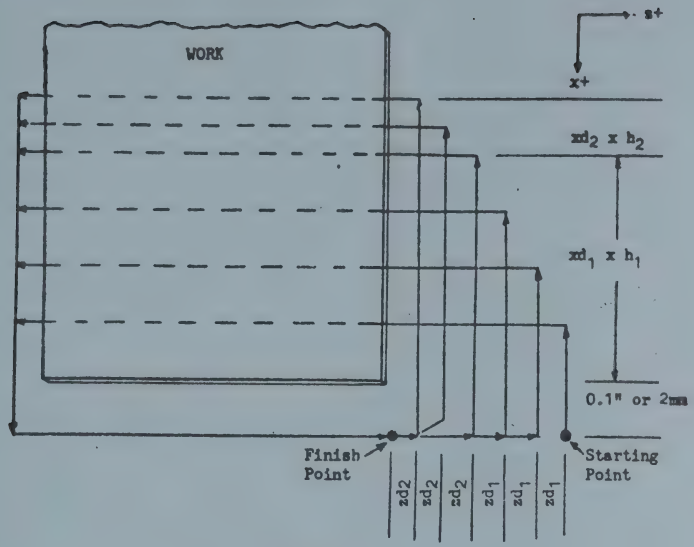


Figure 17
UNIFORM DIAMETER-COMPOUND FEED THREADING

n0001 g83 $\pm$xd$_1$ $\pm$zd$_1$ h$_1$

n0002 g01 (g33, g34, g35) $\pm$z k f

n0003 g84 $\pm$xd$_2$ $\pm$zd$_2$ h$_2$

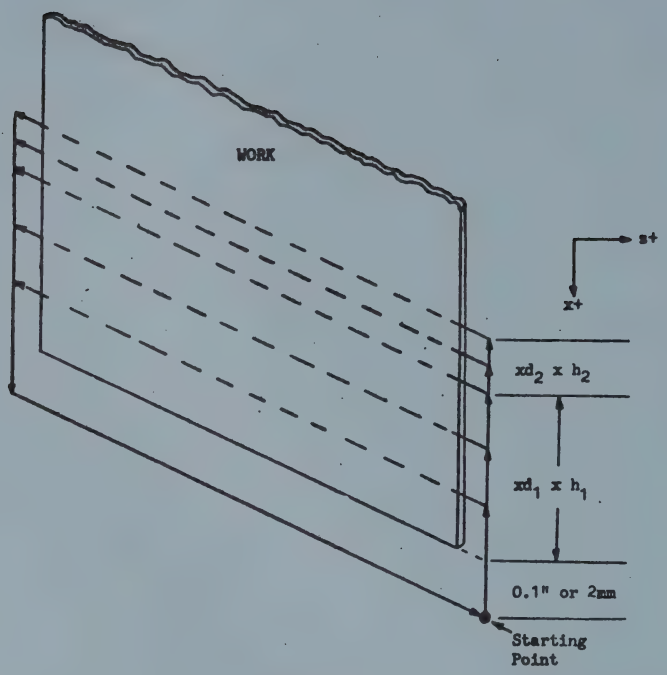


Figure 18
TAPERED WORKPIECE-PLUNGE FEED THREADING OR ROUGHING

n0001 g83 $\pm xd_1$ h_1

n0002 g01 (g33) $\pm x$ $\pm z$ i k f

n0003 g84 $\pm xd_2$ h_2

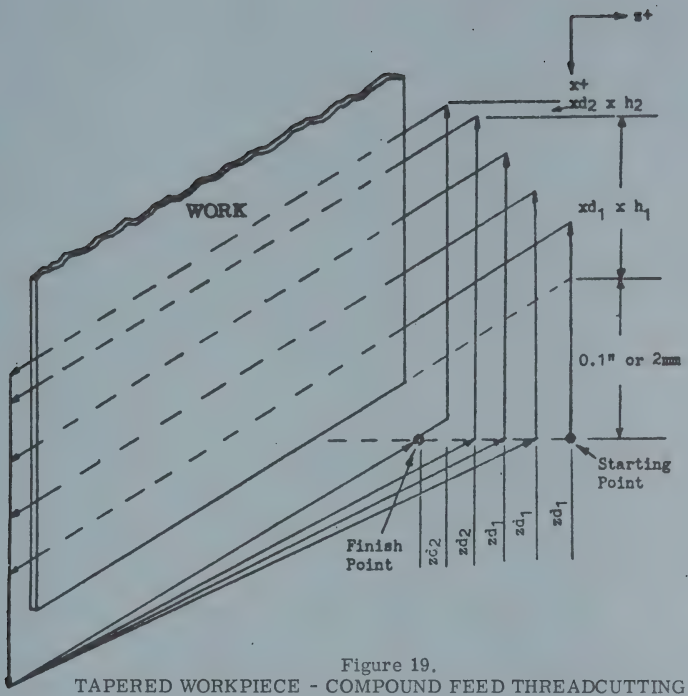


Figure 19.
TAPERED WORKPIECE - COMPOUND FEED THREADCUTTING

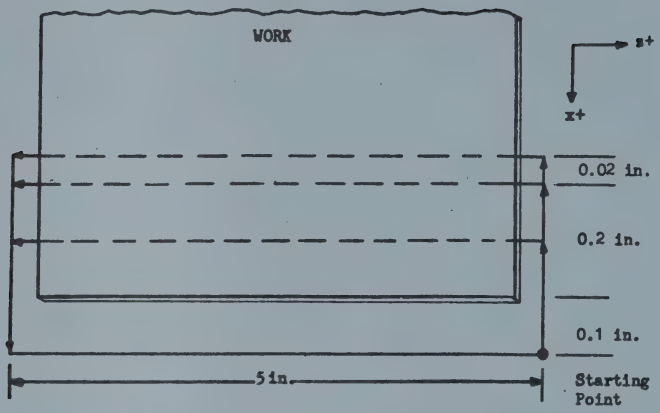
n0001 g83 $\pm xd_1$ $\pm zd_1$ h_1

n0002 g01 (g33) $\pm x$ $\pm z$ i k f

n0003 g84 $\pm xd_2$ $\pm zd_2$ h_2

PROGRAMMING EXAMPLES OF CANNED CYCLES

In all of the following examples, it is assumed that the proper tool has been selected, the spindle has been started and the spindle speed stabilized, and the tool has been positioned to the initial starting point (0.1 inch or 2 mm from the work surface as measured along the x axis).



UNIFORM DIAMETER ROUGHING

Given: The roughing cut is 5 inches long with 2 passes of 0.1 inch and 1 pass of 0.02 inch.

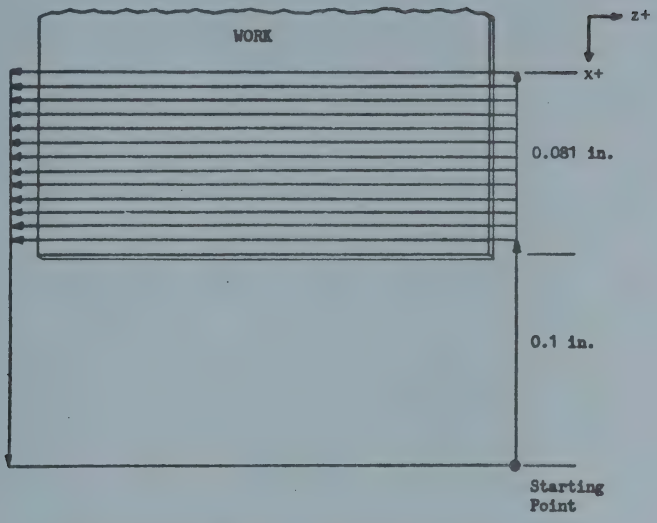
n0001 g83 x-0001 h02 (2 passes of -0.1" each)

n0002 g01 z-005 f02 (linear cut move at 20 ipm)

n0003 g84 x-00002 h01 (1 pass of -0.02")

Note that the final cut depth is the sum of the xd increments for each pass. All non-cutting moves will be made at traverse speed. The cut move will be made at the programmed rate of 20 ipm given in block n0002. All moves are subject to MFO setting and may be stopped with Feedhold.

Given: Cut a 5-inch long thread with a lead of 1/8 inch/rev (8 threads per inch) with a total thread depth of 0.081 inches.



PLUNGE FEED THREADING - CONSTANT LEAD

n0001 g83 x-000008 h07 (7 passes of -0.008 inches each)

n0002 g33 z-005 k0125 (threadcut move at 8 threads/inch)

n0003 g84 x-000006 h02 (2 passes of -0.006 inches each)

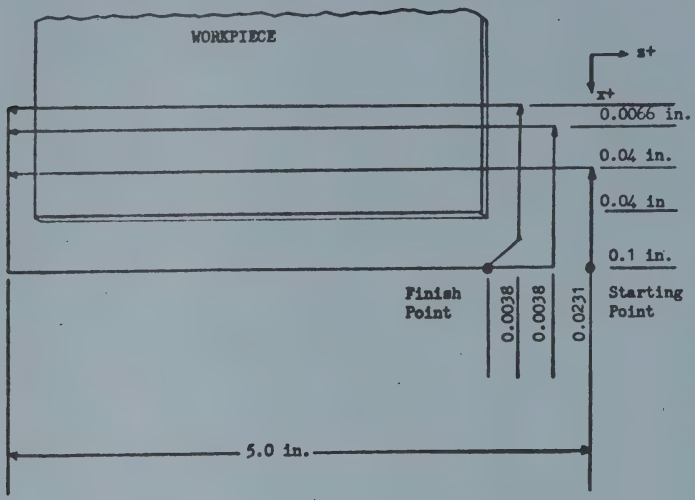
n0004 g84 x-000005 h01 (1 pass of -0.005 inches)

n0005 g84 x-000004 h01 (1 pass of -0.004 inches)

n0006 g84 x-000002 h02 (2 passes of -0.002 inches)

Given: Cut a 5-inch long thread with a lead of 1/10 inch/rev (10 threads per inch) with a total depth of 0.0866 inch.

Make 2 passes with a cut depth of 0.04 inch, and 1 pass of .0066 inch. After the last pass, return to the starting point.



COMPOUND FEED THREADING-CONSTANT LEAD

n0001 g83 x-00004 z-000231 h02 (2 passes of 0.04 in.)

n0002 g33 z-005 k01 (threads move)

n0003 g84 x-000066 z-000038 h01 (1 pass of 0.0066 in.)

n0004 g01 z000307 f0 (return to starting point)

Note - When calculating the distance required to return from the finish point to the start point, one must be aware that the last g84 pass stops short on the return move to the finish point by the amount programmed for z in the last g84 block. In this case, the departure for block n004 was calculated as follows:

	0.0231	- distance z axis was displaced by the
+		2 passes programmed in block n0001.
	0.0038	- distance z axis was displaced by the
+		1 pass programmed in block n0003.
	0.0038	- distance z axis was displaced when the last pass returned to the finish point
	0.0307	inches

Block n0004 is programmed to move the z axis +0.0307 inches in the plus direction, at traverse rate, to return the z axis to the original canned cycle starting point. The finish point is always on a line that runs through the start points along the z axis, so no x departure is necessary in block n0004.

APPLICATION COMMENTS

Thread size control can be accomplished by using canned cycle routines to produce a slightly oversize thread. A programmed stop (m00) permits the operator to measure the thread with appropriate gages after the canned cycle passes are completed. An additional canned cycle or canned cycles can be programmed using the g84 command. The m code may not be programmed in a block with canned cycle data. If the thread is oversize, another canned cycle is available when the operator depresses the Cycle Start pushbutton. If additional canned cycles are not required, the Block Delete pushbutton can be used to skip any or all blocks containing additional canned cycles that are not required.

The final cut depth will always be the sum of the xd increments times the number of passes made for each increment. If the cut is made on a taper (moving both the x and z axes), the above statement still holds true for the final cut depth. However, the programmer must be aware of the fact that any one of the individual passes will be less than the xd increment. The actual metal removed for a given pass is a function of the taper of the workpiece, and the xd increment programmed. If the taper is slight, and the actual variance of cut depth per pass is insignificant, one can merely calculate the total cut depth desired, and disregard the fact that each pass will remove slightly less metal than the xd value programmed.

For linear shafts, the cut depth per pass will always be exactly that programmed for xd.

In choosing the starting point for a canned cycle, the programmer must be aware that all non-metal cutting moves are made at traverse rate (subject to MFO setting). The intent of the canned cycle is to enter and remove the tool from the part (x axis moves) in free air. For some applications this may require precutting a relief shoulder, to permit traversing the tool toward the part before any cuts are made.

When cutting threads using compound feeds (programming both xd and zd), the start point must be selected so that the increments for the x and z axes for each pass can accumulate without interfering with the workpiece. (See Figures 1 through 4).

Figure 4 shows a tapered workpiece on which a compound feed thread is being cut. Note that the return moves for each pass are NOT parallel to the work, and after each pass, the tool finish point is closer to the part than on the previous pass. The total accumulation of zd increments cannot be large enough to allow interference with the part on the return or entry moves.

GEK-36091A

PARAMETRIC SUBROUTINE OPTION FOR THE 1050T CONTROL

NOVEMBER, 1978

PREFACE

The over-all organization for this publication is shown in the Table of Contents (page ii).

A variety of examples are included in Section 10 to aid you in preparing your programs. A description of each example and the page where it is located are given below.

Example	Code	Caption	Page
1	L50	Rough Turning Cycle With Liftoff	18
2	L51	Rough Turning Cycle With Shoulder Cut Toward Chuck	19
3	L52	Rough Turning Cycle With Shoulder Cut Away from Chuck	20
4	L53	Rough Facing Cycle With Liftoff	21
5	L54	Rough Facing Cycle With Taper - Below Center Line	22
6	L55	Rough Facing Cycle With Taper - Above Center Line	23
7	L56	Grooving Cycle - Tapered, Against Chuck	24
8	L57	Grooving Cycle - Tapered, Away from Chuck	25
9	L58	Grooving Cycle - Tapered On A Face, Above Center Line	26
10	L59	Grooving Cycle - Tapered On A Face, Below Center Line	27
11	L60	Grooving Cycle - On A Shaft	28
12	L61	Grooving Cycle - On A Face	29
13	L62	Longitudinal (Tapered) Thread, Entry In x, Plunge Feed	30
14	L63	Longitudinal (Tapered) Thread, Plunge Feed With Rapid Pull Out	31
15	L64	Longitudinal (Tapered) Thread, Plunge Feed With Rapid Pull Out	32
16	L65	Longitudinal Thread With Compound In-Feed	33
17	L66	Deep Hole Drilling Cycle With Liftoff	34

For those who need or want to understand the Subroutine option in greater depth, we have described the processes the Control goes through in order to cut the parts shown in examples 2 and 16. This information is given in Section 11, Tables 1 and 2.

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Operating Modes and Readout	8	15
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SECTION 1
GENERAL DESCRIPTION

The Parametric Subroutine option allows the programmer to save time by using canned cycles that he writes himself.

Parametric subroutines may be used in 3 different ways:

1. A series of fixed part program blocks can be stored in the Control and called up for execution by the active program.

2. A series of parametric part program blocks can be stored in the Control and called up for execution by the active program. In this case the programmer decides which sequence of motions are common on his parts and machines, and ignores the dimensions when writing the subroutines. With parametric subroutines a sequence of moves is programmed less the values, and the values are inserted when the part program is called for.

The idea is similar to tool offsets. The programmer decides to use an offset during a cut but he does not put in the value of the offset; the operator does. When the Control reads the offset code, it looks into its memory for the value the operator inserted.

In Parametric subroutines the programmer puts in the necessary value when he writes the part program and he does so when writing the block that calls up the subroutine. This is termed the "call block". The programmer inserts the dimensional values that the part being made now requires.

3. A series of fixed or parametric part program blocks can be stored in the Control and called up for repetitive execution by the active program.

A subroutine may be repeated up to 99 times per call.

With the Subroutine option, it is possible to store, modify, and execute repetitive programs for cutting operations such as threading, roughing, finishing, etc. Subroutines are stored in the Control's memory and called up by the part program or by another subroutine.

NOTE: The Control must have the Program Storage option in order to use the Subroutine option.

Subroutines are called by the letter address "L" followed by a 4-digit statement.

Example: LXXYY where L = Subroutine letter address
XX = Subroutine number
YY = Number of passes

SECTION 2
NUMBER ASSIGNMENT

Subroutines are assigned numbers L00 through L99 as described below.

L00

L00 is a special code used to terminate each subroutine.

L99

L99 is a dummy subroutine used to change parameters without any program action. Detailed information is given on page 7.

L01 THROUGH L98

There is no difference in how L01 through L98 are executed when they are called by the active program.

However, 3 blocks of numbers: L01 through L49, L50 through L79, and L80 through 98, are used to control the manner in which a subroutine is deleted from memory.

Block No. 1 - L01 through L49

These subroutines are automatically deleted from memory by operating the Clear pushbutton or when the Control executes an m02 or m30 code.

Block No. 2 - L50 through L79

L50 through L79 subroutines are retained in memory until they are deleted by the operator (using the Part Program Delete sequence).

Block No. 3 - L80 through L98

These subroutines are permanently retained in memory and cannot be deleted.

More detailed information on how to delete subroutines is given on page 11.

SECTION 3
PROGRAMMING

The programmer must decide what operations he wants the subroutine to perform. If he does not already have an appropriate subroutine to perform a specific operation, he must design one. Then, after the subroutine has been designed, the part program can be written.

Guides to aid the programmer when he designs and uses subroutines are given below. Also, examples of typical subroutines are given on page . Subroutines can be programmed like normal part programs with numerical dimension values already defined or with parameter programming. This section will first give information on how to design a Subroutine that does not use parameters. Then it will explain how to design a subroutine that does use parameters.

DESIGNING A SUBROUTINE THAT DOES NOT USE PARAMETERS

Any part program sequence can be executed as a subroutine. Any section of the part program that is used more than once is a likely candidate for a subroutine. However, you cannot make an m00, m01, m02, or an m30 a part of the subroutine. They must remain a part of the active program. Once a subroutine is started it should be allowed to be completely executed. Any subroutine can be called from the active part program or from another subroutine. Using a subroutine to call another subroutine is called "nesting". There is no limit to the number of subroutines that can be called by the nesting method. An example of a nest is given below.

A subroutine can call another subroutine that has a lower or a higher subroutine number. For example, L01 can call L20; L20 can call L05; L05 can call L88, etc. In the preceding example, when L88 completes execution, it returns to L05. When L05 completes execution, it returns to L20. Then L20 returns to L01, and L01 returns to the active program.

A subroutine cannot call itself or any subroutine in its calling nest. For example, L01 can call any of the subroutines except itself. L20 can call any subroutine except itself and L01. L05 can call any subroutine except itself, L20, and L01. In other words a subroutine cannot call itself or a preceding subroutine in the nest.

NOTE: It is more efficient to enter g codes in the part program rather than in the subroutine. When g codes are a part of the subroutine they are repeated unnecessarily each time the subroutine is repeated which increases the subroutine cycle time.

In all cases the return from a subroutine is to the place where the subroutine was called. Execution continues from that point.

Subroutine Format

The first block of a subroutine must contain a $ mark, an L code, and a 2-digit number (01-98) followed by an EOB.

This information is then followed by the part program sequence that makes up the subroutine. The subroutine is terminated by an L00 at the end of the last block. Part program data is indicated by periods.

Example:	$L50	Subroutine number
	n0001...	
	n0002...	Part program sequence
	n0003...	
	n0004...	
	n0005... L00	Last block of data contains subroutine termination.

NOTE: Early designs required the L00 to be in a block by itself.

More detailed information on subroutine formats is given on page 8.

DESIGNING A SUBROUTINE THAT USES PARAMETERS

NOTE: All of the preceding information under "Designing A Subroutine That Does Not Use Parameters" also applies to this section.

Any of the numeric data (departures, feeds, and speeds) in a part program can be replaced by a parameter. All words (n, g, x, z, i, k, r, f, s, t, m) can be used with one parameter. When they use one parameter, they are called "single parameter" words.

Also, dimension and feedrate words (x, z, i, k, r, and f) can have one, two, or three parameters. When dimension and feedrate words use more than one parameter, they are called "multi-parameter" words. Multi-parameter words are used to increment or decrement the value of the parameter in the parameter table on successive passes through the subroutine.

A ";" symbol (RS-358 tracks 1, 2, 4, 5, 6, and 8) or an "&" symbol (RS-244 tracks 2, 3, and 4) precedes and identifies a parameter number. The parameter number is put in the subroutine as a substitute for the data that will actually be used. The paramater number calls up the actual data from the parameter table.

The data in the parameter table will have been previously supplied by the calling blocks (described later on page). The parameter table will be described next. After that, we will explain how parameters are used in a subroutine: how single and multi-parameter words can be assigned to a word; how parameter signs can be used to increment and decrement parameters; and the use of the L9900 subroutine. Finally, the method of calling a subroutine form the part program will be explained.

Parameter Table

Memory is reserved in the 1050 Control for the parameter table. Sixteen parameters, each containing 7 digits, can be stored. Leading zeroes can be omitted.

The parameter values are supplied by the programmer in the subroutine calling block when he wants to use them. Once a value has been put in the parameter table, it can only be changed in 2 ways; it can be replaced by another value (in a later calling block) or it can be changed if it is incremented or decremented by a multi-parameter word. Multi-parameter words are described below.

Single Parameter Word

A single parameter word allows each calling block to specify a different value for a parameter when that value does not need to be incremented or decremented.

For example, parameter 01 could be used to specify a feed rate of 100 ipm in a calling block. In a later calling block for the same subroutine, the feed rate could be specified at 65 ipm.

Another example would be to use parameter 02 to specify a z dimension of 10 mm in a calling block. In a later calling block, a z dimension of 20 mm could be specified.

In other words, you can keep the parameter value that you already have (in the parameter table) or you can change the parameter value in each calling block.

Multi-Parameter Word

The programmer can use either a two-parameter or a three-parameter word.

Two-Parameter Word

A two-parameter word allows incrementing or decrementing the first parameter value each pass through the subroutine.

Example: g01x;01;02

The absolute value of parameter 02 is added to or substracted from the absolute value of parameter 01 each pass through the subroutine.

Three-Parameter Word

A three-parameter word allows the third parameter to increment or decrement the second parameter value each pass through the subroutine.

Example: g01x;01;02;03

The value of parameter 02 is combined with the value of parameter 01 for all passes. Then the value of parameter 03 is combined with the value of parameter 02.

Use of Parameter Signs

It is important to understand the relationship of the plus and minus signs on parameter values in the calling block in combination with the signs of the parameter numbers within the subroutine.

First Parameter

A plus or minus sign can be programmed for the parameter value in the calling block and/or with the parameter number in the subroutine. The sign must always follow the semi-colon.

For dimension words, the direction of motion is determined by combining the sign of the value assigned to the parameter in the calling block and the sign of the parameter number within the subroutine. If both signs are alike, motion is plus; if both signs are not alike, motion is minus.

Example: Subroutine definition - n0001 x;-01
Calling block - L2001 ;-01000

The resulting sign of x motion would be plus, since both signs are alike (minus, minus). See the following table.

Parameter 1:				
Parametric Value	+	+	-	-
Call Block	+	-	+	-
Direction of Move	+	-	-	+

Second Parameter

For a two or three-parameter word, the combination of the signs of the second parameter value assigned in the calling block and the sign of the second parameter number within the subroutine, determine whether the absolute value of the second parameter is added to or subtracted from the absolute value of the first parameter for each pass through the subroutine.

Example: Subroutine block - n0001 x;-01 ;02
Calling block - L0102 ;-01000 ;-00100

In this example, the direction of move is plus (signs of parameter number 01 and its value are alike, but since the signs of parameter 02 and the value assigned to it are not alike, the absolute value of parameter 02 will be subtracted from the absolute value of parameter 01).

Parameters 2 and 3:				
Parametric Value	+	+	-	-
Call Block	+	-	+	-
Change	+	-	-	+

In summary, if signs are alike, the absolute value of the first parameter is incremented. If signs are not alike, the absolute value of the first parameter is decremented.

Third Parameter

The third parameter is combined with the second parameter in the same way as the second is to the first, as described above. Note however, that the effect of the third parameter is not seen on the first parameter until the second pass.

Decrementing a Parameter Through Zero

If the value of any parameter is decremented through zero, the value goes to zero and remains at zero. The sign does not change. The parameter value remains a zero until it is re-programmed.

Incrementing and Decrementing Parameters

The same parameter number can be used in more than one block within a subroutine. The value of the parameter may be incremented or decremented by a second or a third parameter in the same word. Once a parameter value has been incremented or decremented, the resultant new value is stored in the parameter table. Since this new value is now in the parameter table, it will be used when the parameter number appears later in another block or word.

Parameter Used in More Than One Block

For example, parameter 07 is used in blocks 6202 and 6204 in the subroutine shown below. Also, it is combined with a second parameter (02) in block 6202.

```
g25
$ L62
n6201 g91
n6202 g21 x;-07;-02 f00
n6203 g33 z;01 k;03
n6204 g01 x;07 f00
n6205 z;-01
L00
g26
```

Assume the following current values

Parameter 07 is +0. 1 inch
Parameter 02 is +0. 005 inch

In sequence n6202 the x word has two parameters: 07 which has a value of +0. 1 inch and 02 which has a value of +0. 005 inch. When 6202 is executed, these values are combined and the new value for parameter 07 is now 0. 095 inch which is immediately stored in the parameter table for parameter 07.

Then in block 6204 when parameter 07 is executed, its value in the parameter table is 0. 095.

Machine moves caused by executing the above blocks are as follows. For the first pass in sequence n6202, the x move is -0. 095 inch (and +0. 095 is the new value in the parameter table). When block n6204 is executed, the x move is +0. 095 inch.

In the second pass when sequence n6202 is executed, the x move is -0. 090 inch (+0. 090 is the new value in the parameter table). When sequence n6204 is executed, the x move is +0. 090 inch.

Table 1, page 6 shows the values in the parameter table for parameters 07 and 02 after each of the above passes. It also shows the resultant machine moves.

TABLE 1

PARAMETER TABLE DATA

	FIRST PASS			SECOND PASS		
	BEFORE BLOCK 6202 IS EXECUTED	AFTER BLOCK 6202 IS EXECUTED	AFTER BLOCK 6204 IS EXECUTED	BEFORE BLOCK 6202 IS EXECUTED	AFTER BLOCK 6202 IS EXECUTED	AFTER BLOCK 6204 IS EXECUTED
Parameter 07	+0.1	+0.095	+0.095	+0.095	+0.090	+0.090
Parameter 02	+0.005	+0.005	+0.005	+0.005	+0.005	+0.005
Machine Movement		-0.095	+0.095		-0.090	+0.090

Please note that machine movement takes place only after parameters 07 and 02 are combined.

Parameter Used In More Than One Word Within A Block

If a parameter is used with different words in the same block, the parameter value is changed when the multi-parameter word is processed.

NOTE: Words are processed in the sequence specified by EIA Standard RS-274 regardless of the order in which they appear in the part program block.

An example of a parameter used in 2 words in the same block follows:

n0001 g01 x;01z;01;02

If the above block is performed 3 times, the parameter combination sequence and the distances to move in x and z are shown in the table below.

Assume a value of 3 inches for parameter 01 and 0.5 inch for parameter 2.

Arithmetic takes place when the z word is processed because z has 2 parameters.

Parameter Combination Sequence			Distance to Move for x and z	
PASS	x	z	x	z
1	01	01+02	3.0	3.0 + 0.5 = 3.5
2	(01+02)	(01+02) + 02	3.5	3.5 + 0.5 = 4.0
3	(01+02+02)	(01+ 02+02) + 02	4.0	4.0 + 0.5 = 4.5

L99 Subroutine

If a calling block has to be programmed that contains more parameter values than can be written on one line of the manuscript before the carriage return is reached, the L9900 calling block can be used to call any number of excess parameter values. L9900 must precede the subroutine calling block. A semicolon must be placed before each parameter value.

Example: L9900 ;1;2;3;4;5;6
L5005 ;;;;;;;7;8;9;10;11;12;13;14;15;16;

In the above example, subroutine L5005 is called for 5 passes and 16 parameter values are needed. (Numbers 1 through 16 indicate values.) The first 6 parameters are programmed in the L9900 block. The L9900 block does not cause any action, but fills in the first 6 positions of the parameter table.

The L5005 block contains 6 semicolons denoting that the values for the first 6 parameters are already in the parameter table. The remaining parameter values (7-16) are then programmed preceded by a semicolon. Any number of L9900 blocks may be used.

Calling A Subroutine From A Part Program

A calling block can be inserted in the active program or in another subroutine to execute a subroutine.

A subroutine can be repeated up to 99 times as specified in the calling block.

The format of the calling block is LXXYY where

L = Subroutine letter address
XX = Subroutine number
YY = Number of passes

The calling block must also contain any parameter values used in this subroutine. The subroutine calling block may also include other data as long as the LXXYY and the parameter values are the last items in the block.

M stop codes m00, m01, m02, or m30 cannot be included in a subroutine calling block or within a subroutine.

When specifying parameter values in the calling block, the parameter numbers are not used. A semicolon (;) identifies each parameter in the RS-358 code and an ampersand (&) in the RS-244 code.

Example: L0101 ; 2 ; ; 1000 ; 2000 ; 0

Parameter 1 = 2
2 = Uses value presently in parameter table
3 = 1000
4 = 2000
5 = 0

In the example above, the first semicolon identifies the first parameter (2), the second semicolon identifies the second parameter (which is the value presently in the parameter table), the third identifies the third parameter (1000), etc. All parameter values are programmed Omit Leading Zeroes.

The format of a parameter value programmed in a calling block is the same as the word it is assigned to.

TAPE PREPARATION

Subroutine data can be physically located on a tape by itself, on the part program tape, on the Executive tape, or on the Machine Setup Data tape.

SUBROUTINE ON A TAPE BY ITSELF

Subroutines L50 through L98 can be put on a separate tape. Subroutines L01 through L49 cannot be put on this tape.

PART PROGRAM TAPE

If the subroutine data is put on the part program tape, the subroutine data must precede the part program data.

Subroutines L01 through L49 must be put on this tape. Subroutines L50 through L98 cannot be put on this tape.

EXECUTIVE TAPE

The subroutine data (L50 through L98) can be spliced at the end of the executive tape along with Machine Setup Data. However, the subroutine data must precede the L1002/L1030 code on the Machine Setup Data tape.

Subroutines L01 through L49 cannot be put on the executive tape.

MACHINE SETUP DATA TAPE

The subroutine data (L50 through L98) must precede the L1002/L1030 code if it is put on the Machine Setup Data tape. If there are more than one Machine Setup Data tapes, it does not matter which one contains the subroutine data.

Subroutines L01 through L49 cannot be put on the Machine Setup Data tape.

TAPE FORMAT

Tape format for subroutine design and for calling blocks are described below.

FORMAT FOR SUBROUTINE DESIGN

The general format for general subroutine design is as follows:

```
EOB
g25

One or more subroutines
each starting with $LXX
and ending with L00
(XX = 01-98 = subroutine number)

g26
EOB
```

Any part program data can be included in a subroutine with the exception of m stop codes (m00, m01, m02, m30).

Specific formats for subroutines stored on Executive tape, Machine Setup Data tape, Part Program tape or on a tape by itself are given below.

Executive Tape, Machine Setup Tape, or Tape by Itself

If the subroutine data is on the Executive tape or Machine Setup Data tape, the subroutine data must precede the L1002 or L1030 code. Examples for one subroutine or several subroutines are given below.

One Subroutine Only:

```
EOB    (End of Block)
g25    (Beginning of the Subroutines) EOB
$LXX   (Number of the Subroutine) EOB
  :
  :    SUBROUTINE
  :
L00    (End of the Subroutine) EOB
g26    (After the last Subroutine) EOB
```

Several Subroutines:

```
EOB    (End of Block)
g25    (Beginning of the Subroutines) EOB
$LXX   (Number of the Subroutine) EOB
  :
  :    SUBROUTINE #1
  :
L00    (End of the Subroutine) EOB
$LXX   (Number of the Subroutine) EOB
  :
  :    SUBROUTINE #2
  :
L00    (End of the Subroutine) EOB
$LXX   (Number of Subroutine) EOB
  :
  :    SUBROUTINE - Last
  :
L00    (End of Subroutine) EOB
g26    (After the last Subroutine) EOB
```

Part Program Tape

Subroutines L01 through L49 are stored as a part of the part program and must have the format shown below:

```
Stop Code   (% in RS-358, EOR in RS-244 code)
EOB
$123456     (Part Program Identification)
g25         (Beginning of Subroutines) EOB
$LXX        (One or more subroutines, each
             starting with LXX, where XX
             indicates the number of sub-
             routine) EOB
  :                          .
  :
L00         (End of each Subroutine) EOB
g26         (All Subroutines complete) EOB
n001        (Beginning of the Part Program)
  :
  :
  :
  :
m02/m30     (End of the Part Program and
             Clearing Memory from Sub-
             routines Number L01 through
             L49) EOB
Stop Code
```

Format for Calling Block

A calling block causes a subroutine to be executed. It may be placed in a part program or in another subroutine. A calling block consists of letter address L followed by 4 digits and the parameter values used in that subroutine.

Example: LXXYY

XX = Subroutine number
YY = Number of passes

Subroutine numbers can be from L01 through L99. The number of passes can be from 00 through 99. If 00 or 01 is used, one pass will be executed. Up to 16 parameter values (each preceded by a semicolon) can also be included in the block.

See Programming, page 7 for detailed information on designing calling blocks.

SECTION 4
LOADING

There are four methods for loading subroutine data into the program storage area: subroutine data is a part of the executive tape; subroutine data is a part of a machine setup data tape; subroutine is on a tape by itself; subroutine data located on the part program tape.

METHOD 1
SUBROUTINE DATA IS A PART OF THE EXECUTIVE TAPE

Load the executive tape containing the subroutine data in the same manner that you would load any executive tape. The subroutine data must precede the L1002/L1030 code.

L01-L49

Cannot be loaded this way.

L50-L79

May be loaded this way; however, they may be inadvertently deleted which would require reloading the Executive tape.

L80-L98

Recommended method of loading.

METHOD 2
SUBROUTINE DATA IS A PART OF A MACHINE SETUP DATA TAPE

Load the Machine Setup Data in the same manner that you would load any Machine Setup Data tape. The subroutine data must precede the L1002/L1030 code.

L01-L49

Cannot be loaded this way.

L50-L79

May be loaded this way; however, they may be inadvertently deleted which would require reloading the Executive tape.

L80-L98

Recommended method of loading.

METHOD 3
SUBROUTINE IS ON A TAPE BY ITSELF

A Subroutine that is on a tape by itself can be loaded in 3 different ways. The 3 ways are identical except for the way loading is initiated.

Store Program

Load the subroutine tape in the same manner that you would load any part program tape using the Store Program pushbutton.

Wind Forward

Put the Subroutine tape in the reader and push Wind Forward.

Cycle Start

Put the Subroutine tape in the reader and push Cycle Start.

L01-L49

Cannot be loaded this way.

L50-L79

Recommended method of loading.

L80-L98

May be loaded this way if Method 1 or Method 2 is not used.

METHOD 4
SUBROUTINE DATA IS LOCATED ON THE PART PROGRAM TAPE

Load the tape as you would load any part program tape. The subroutine is now stored in memory as part of the part program.

When this part program is executed, the subroutine is copied into another section of part program memory. When the part program is completed (an m02, m30 is executed or the clear pushbutton is depressed) the duplicated subroutine data is deleted.

L01-L49

Recommended method of loading.

L50-L79

Cannot be loaded this way.

L80-L99

Cannot be loaded this way.

Note

When the part program is executed from the tape reader, the following sequence takes place.

1. When Cycle Start is depressed the subroutine is loaded into part program storage.
2. The part program begins execution.
3. The calling block executes the subroutine.
4. When an m02 or m30 is executed or when the Clear pushbutton is depressed, the subroutine data is deleted.

SECTION 5
DELETING

Depending on the number assignment, subroutines are deleted automatically or by the operator. Some subroutines cannot be deleted.

L01 THROUGH L49

Subroutines L01 through L49 are automatically deleted by m02, m30, or Clear. The automatic deletion of these subroutines ensures that special job-oriented subroutines are automatically deleted whenever the part program is taken off the machine.

If a tape containing the combination of subroutines in the leader followed by the part program has been loaded into memory using one part program ID for the entire tape, the complete tape, including the subroutines can be deleted using the DELETE function.

L50 THROUGH L79

Subroutines L50 through L79 are maintained in memory unless they are deleted in the same manner that any part program would be deleted.

L80 THROUGH L98

Subroutines L80 through L98 cannot be deleted and are permanently maintained in memory as long as the Control software is loaded.

SECTION 6
EDITING

The Edit mode is used to modify, delete, and add subroutine blocks. Some rules for subroutine editing follow:

1. Call the subroutine and turn the Edit switch to the EDIT position.

2. Once the subroutine is called, use Wind Forward to search for the desired block. Rewind is not operative when a subroutine is active.

3. When editing, the ";" is generated by depressing the Next pushbutton.

4. To add a block, clear the buffer by using the following procedure.

   A. Turn the Edit switch to EDIT.

   B. Turn the Selector switch to ADD BLOCK.

   C. Turn the Letter Address switch to (/).

   D. Depress the Next pushbutton.

   E. Enter a block using the MDI keyboard and the Letter Address switch.

   F. Depress the Part Program Edit pushbutton to store the new block.

NOTE: When editing the L word or any parameter in a call block all parameters are erased and must be reentered.

Also when editing parameter numbers in a subroutine all of the numbers must be reentered whether they changed or not.

The following is an example of a subroutine with an error and how to change it.

Subroutine As Stored

```
g25
$ L52
n3001  x - ; 01 ; -02 ; 03 f01
       (should be x ; 01 ; -02 ; 03)
n3002  z005
n3003  x - ; 01 (should be x ; -01)
n3004  z-005
L00
g26
```

To Edit

1. Select MDI and enter L5200.

2. Initiate Cycle Start to call the subroutine.

3. Wind Forward one block and block n3001 is displayed.

NOTE: Rewind is not operative when a subroutine is active.

4. Turn on Edit if it is not already on.

5. Select x.

6. Depress Next 01, Next -02, Next 03.

When editing parameter numbers all of the numbers must be reentered whether they changed or not.

7. Depress the Edit pushbutton to perform Edit.

8. Continue forward to modify block n3003.

9. When you are through editing, wind forward through L00 to exit the subroutine.

SECTION 7
PUNCH

If the system includes the punch option, subroutine tapes can be punched out using the same procedure as used for programs. The tape which is produced will have the g25 inserted at the beginning and the g26 at the end as required.

SECTION 8
OPERATING MODES AND READOUT

Calling blocks and subroutines can be executed in the Auto and Single modes. Calling blocks can be entered, modified and executed in the MDI mode. It is then necessary to switch to the Auto or Single mode to execute the subroutine.

AUTO MODE

Subroutines can be initiated and executed in the Auto mode. Normal automatic operation occurs. After the subroutine is executed, if there is an active program, it continues.

If the subroutine is being executed in the Auto mode and the operator changes the mode (such as to Single or MDI) the Control executes all blocks in buffer before it switches to the new mode of operation.

SINGLE MODE

Subroutines can be initiated and executed in the Single mode. Normal single block operation occurs. After the subroutine is executed, if there is an active program, it continues.

MDI MODE

If the subroutine is already stored, the calling block can be entered, modified, and initiated in the MDI mode. To modify an existing calling block (in the part program) first read this block into the buffer using the Wind Forward switch. The precedure for entering or modifying parameters is the same as for words and blocks of a part program. For better understanding it is described again below:

1. Select L on the letter address switch. Now, the existing L number can be changed or a new L number can be entered. If the L number is changed, any parameter in the call block is erased and must be reentered.

2. Depress the Next pushbutton and the display indicates 01 for parameter number 01. Entries or modifications of the parameter value assigned to parameter 01 now can be made.

3. Each time the Next pushbutton is depressed, the next parameter number appears on the readout and the value assigned to it can be either entered or changed. If no entry or change is made for a particular parameter, it stays as it is shown on the readout.

4. Parameter number 01 can be obtained at any time by switching the letter address switch off and back on L and depressing the Next pushbutton.

The calling block is now in buffer. The procedure for executing the subroutine is given below.

1. Switch to either the Auto or the Single mode.

2. Push Cycle Start. If auto was selected, the complete subroutine is executed. If Single was selected, the subroutine is executed block by block.

READOUT

To display the current parameters which are the result of the latest pass of the subroutine, cycle start must not be active and the display switch has to be in the STATUS position for the 256-character readout or in the ACTIVE position for the 32-character readout. In addition, the letter address switch must be in the L position.

When a subroutine block is entered into buffer using the Wind Forward switch, the tape image is shown.

Example: n0001 g01 x ; 01 ; -02

Each subroutine calling block displayed on the readout shows the active subroutine number and the number of passes still to be done.

SECTION 9
ERROR DETECTION

The subroutine option monitors for a limited number of format errors. When they occur, the program is stopped in the same manner as for a read error and SUBROUTINE ERROR is displayed. When this happens, what has been prepared by the software can be displayed in buffer using Wind Forward even though the block cannot be executed. Always refer to the manuscript to reconstruct the block (without the error). For some cases the block will be completely blank and must be totally reconstructed. Those errors causing the SUBROUTINE ERROR message are:

1. Call for a subroutine which is not stored. For this case, the Control must be cleared, the subroutine loaded and then the program restarted. If the program was there, but there was an error in the subroutine number, then turn on EDIT, make the change, and continue with the program.

The rest of the errors can be edited without the Control being cleared, and the program continued.

2. A plus or minus before the ";" for a word

   x - ; 01 (Should be x ; -01)

3. A parameter without 2 digits

   x ; 1 ; 02 (Should be "01")

4. A parameter number of "00" or more than 16.

5. More than 3 parameters assigned to a dimension or feed rate word.

6. More than 1 parameter assigned to any other word.

SECTION 10
EXAMPLES

The following examples are shown to help the user learn about the subroutine function. Also, they can be used unchanged for many applications, or they can be modified for specific applications.

These subroutines have been designed so that they may be used immediately by punching them onto a tape and loading them into the Control.

The actual dimensions of the respective cuts may be specified using parameters (variables applied to various addresses). The subroutine calling block specifies the subroutine name, the number of passes, and the parameter values.

To make the examples easier to understand, all of the programs for the subroutines have been written in incremental programming. The programmer will find that in several cases absolute programming is advantageous and he may wish to develop his own subroutines.

Although the use of parameters allows full flexibility with respect to assignment of parameters to address letters, for these examples the same parameter number is used for the same function as much as possible. For example, parameter number 1 is used as length of cut, parameter number 2 for in-feed value, and parameter number 6 as feed rate. By using the same parameter number for a specific function as much as possible, the programmer and operator will become more familiar with the parameters being used.

The format of the examples is divided into four quadrants. The upper two (at the top of the page) show a typical example with the drawing on the left and the excerpt from the part program on the right, including the subroutine calling block(s). The lower left sketch shows the possible variations of the cycle, using different parameter signs. Most probably, a specific user will not use all the variations shown; the variations are shown in order to cope with the different possible machine configurations and metal-cutting philosophies.

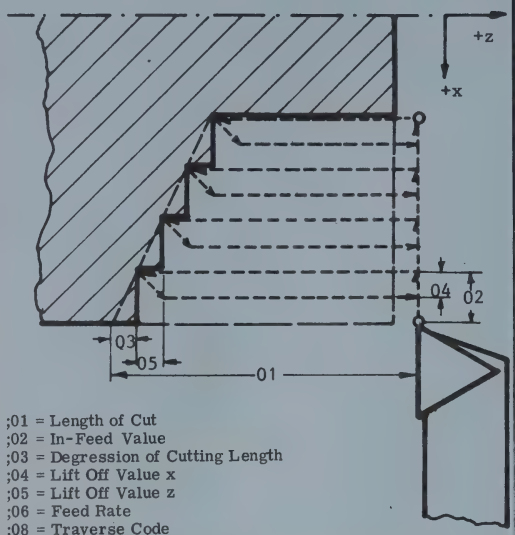
The lower right quadrant shows the subroutine definition including all coding which is required to load the subroutine into memory as a separate, short piece of tape.

The subroutines shown in the examples in total use less than 1500 characters of program storage space.

If the user wants to load all subroutines with one tape, it is sufficient to have g25 only once at the beginning of the tape and g26 only once at the end of the entire subroutine tape (as described in the programming instructions, page 3).

L50	ROUGH TURNING CYCLE WITH LIFTOFF

TYPICAL APPLICATION

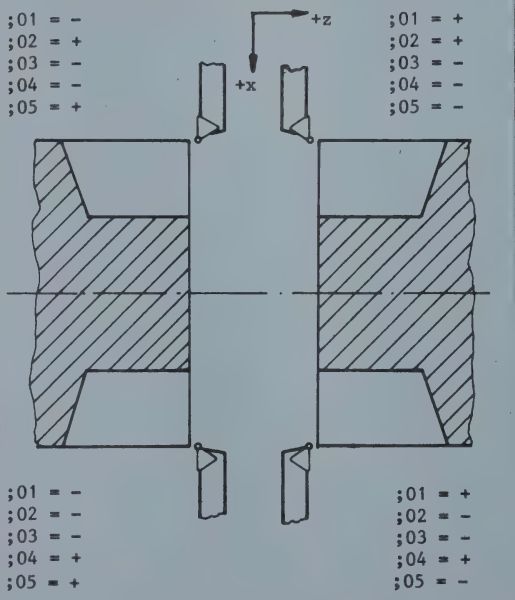


;01 = Length of Cut
;02 = In-Feed Value
;03 = Degression of Cutting Length
;04 = Lift Off Value x
;05 = Lift Off Value z
;06 = Feed Rate
;08 = Traverse Code

PART PROGRAM WITH POSITIONING MOVE FOR STARTING POINT AND SUBROUTINE CALLING BLOCK(S)* INCLUDING PARAMETER VALUES.

```
ϟ
G90
G01   x30000   z165000   F00
G91
*L9900; -30000;  -5000;  -3000;  1000
*L5004;;;;; 1000;  500;;0
G90
G01   x30000
ϟ
```

VARIATIONS OF SETUP BY PARAMETERS' SIGNS



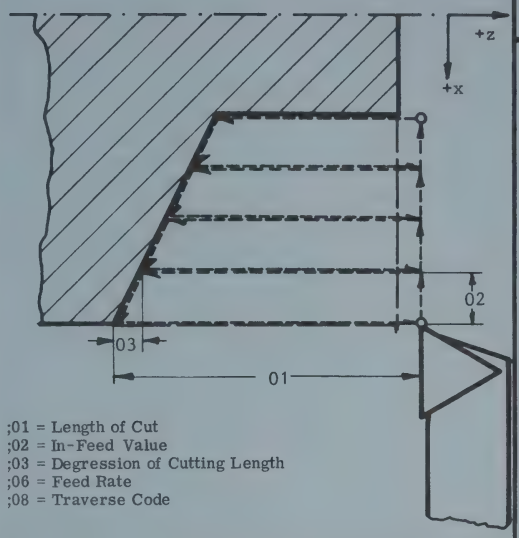
GENERAL SUBROUTINE DEFINITION

```
G25
$L50
N5001   G21   x;02   F;08   M81
N5002   z;01;03   F;06
N5003   x;04   z;05   F;08   M80
N5004   z;-01
N5005   z;-05
N5006   x;-04   L00
G26
```

Example 1.
L50
Rough Turning Cycle With Liftoff

L51	ROUGH TURNING CYCLE WITH SHOULDER CUT TOWARDS CHUCK

TYPICAL APPLICATION

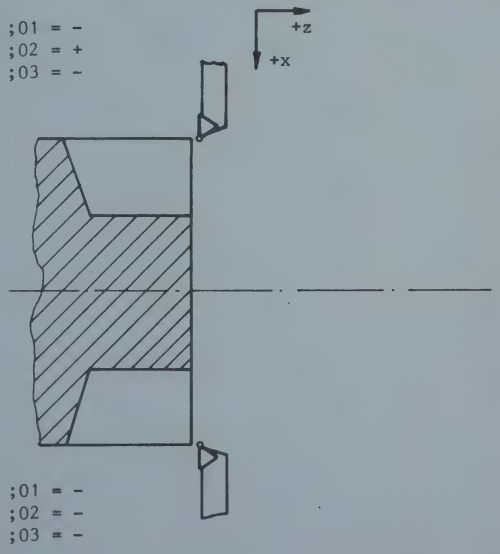


;01 = Length of Cut
;02 = In-Feed Value
;03 = Degression of Cutting Length
;06 = Feed Rate
;08 = Traverse Code

PART PROGRAM WITH POSITIONING MOVE FOR STARTING POINT AND SUBROUTINE CALLING BLOCK(S)* INCLUDING PARAMETER VALUES.

```
ϟ
G90
G01   x30000   z165000   F00
G91
*L5104; -30000; -5000; -2500;;; 500;;0
G90
G01   x30000
ϟ
```

VARIATIONS OF SETUP BY PARAMETERS' SIGNS



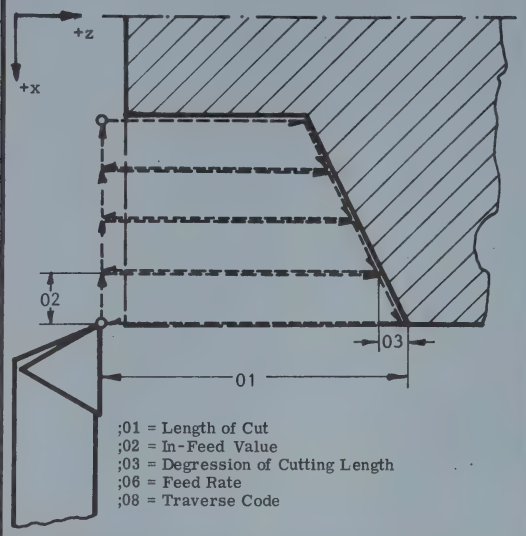
GENERAL SUBROUTINE DEFINITION

```
G25
$L51
N5101   G21   x;02   F;08
N5102   z;01;03   F;06
N5103   x;-02   z;03
N5104   z;-01   F;08
N5105   z;-03
N5106   x;02   L00
G26
```

Example 2.
L51
Rough Turning Cycle With Shoulder Cut Towards Chuck

L52	ROUGH TURNING CYCLE WITH SHOULDER CUT AWAY FROM CHUCK

TYPICAL APPLICATION

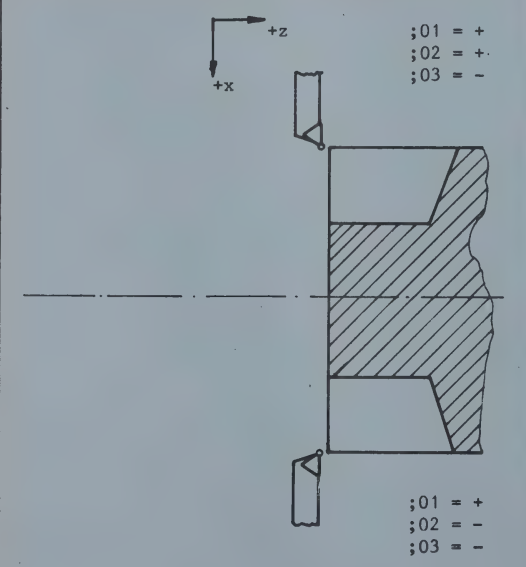


;01 = Length of Cut
;02 = In-Feed Value
;03 = Degression of Cutting Length
;06 = Feed Rate
;08 = Traverse Code

PART PROGRAM WITH POSITIONING MOVE FOR STARTING POINT AND SUBROUTINE CALLING BLOCK(S)* INCLUDING PARAMETER VALUES.

```
ϟ
G90
G01   x30000   z16500   F00
G91
*L9900;   30000;   -5000;   -3000
*L5204;;;;;;500;;0
G90
G01   x30000
ϟ
```

VARIATIONS OF SETUP BY PARAMETERS' SIGNS



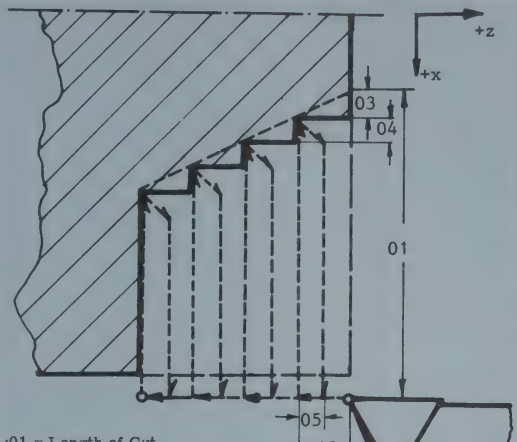
GENERAL SUBROUTINE DEFINITION

```
G25
$L52
N5201   G21   x;02   F;08
N5202   z;01;03   F;06
N5203   x;-02   z;-03
N5204   z;-01   F;08
N5205   z;03
N5206   x;02   L00
G26
```

Example 3.
L52
Rough Turning Cycle With Shoulder Cut Away from Chuck

L53	ROUGH FACING CYCLE WITH LIFT OFF

TYPICAL APPLICATION

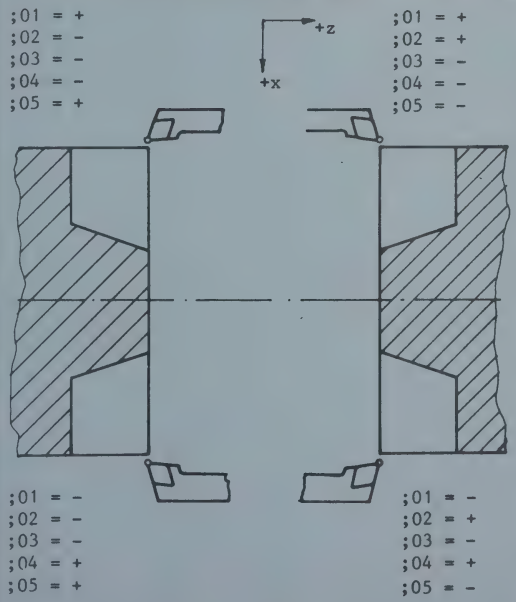


;01 = Length of Cut
;02 = In-Feed Value
;03 = Degression of Cutting Length
;04 = Lift Off Value x
;05 = Lift Off Value z
;06 = Feed Rate
;08 = Traverse Code

PART PROGRAM WITH POSITIONING MOVE FOR STARTING POINT AND SUBROUTINE CALLING BLOCK(S)* INCLUDING PARAMETER VALUES.

```
ϟ
G90
G01   x37500   z165000   F00
G91
*L9900;   -30000;   -5000;   -3000
*L5304;;;;1000;   1000;   500;;0
G90
G01   z165000   F00
ϟ
```

VARIATIONS OF SETUP BY PARAMETERS' SIGNS



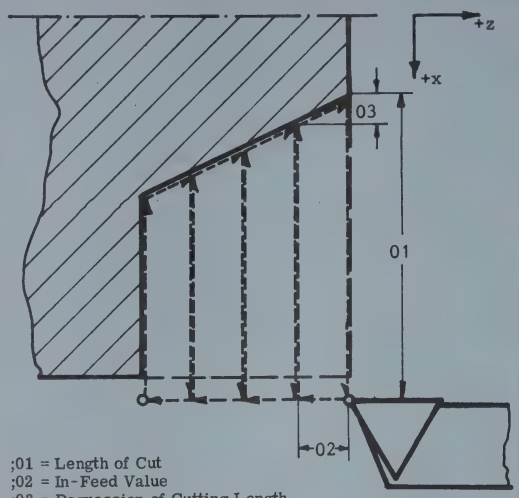
GENERAL SUBROUTINE DEFINITION

```
G25
$L53
N5301   G21   z;02   F;08
N5302   x;01;03   F;06
N5303   x;04   z;05   F;08
N5304   x;-01
N5305   x;-04
N5306   z;-05   L00
G26
```

Example 4.
L53
Rough Facing Cycle With Liftoff

L54	ROUGH FACING CYCLE WITH TAPER - BELOW CENTER LINE

TYPICAL APPLICATION



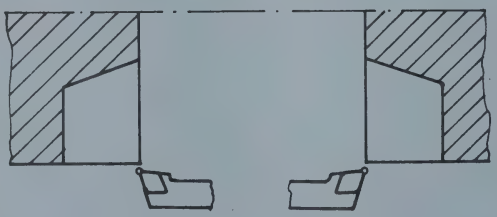
;01 = Length of Cut
;02 = In-Feed Value
;03 = Degression of Cutting Length
;06 = Feed Rate
;08 = Traverse Code

PART PROGRAM WITH POSITIONING MOVE FOR STARTING POINT AND SUBROUTINE CALLING BLOCK(S)* INCLUDING PARAMETER VALUES.

```
%
G90
G01   x37500   z165000   F00
G91
*L9900;   -30000;   -5000;   -3000
*L5404;;;;;;   500;;0
G90
G01   z165000   F00
%
```

VARIATIONS OF SETUP BY PARAMETERS' SIGNS

;01 = -	;01 = -
;02 = -	;02 = +
;03 = -	;03 = -



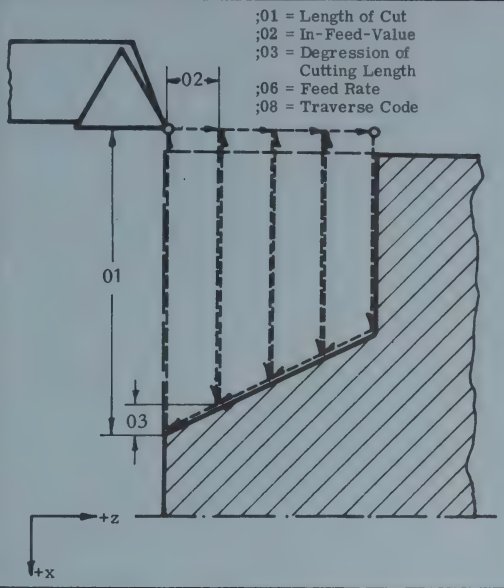
GENERAL SUBROUTINE DEFINITION

```
G25
$L54
N5401   G01   z;02   F;08
N5402   x;01;03   F;06
N5403   x;03   z;-02
N5404   x;-01   F;08
N5405   x;-03
N5406   z;02   L00
G26
```

Example 5.
L54
Rough Facing Cycle With Taper - Below Center Line

L55	ROUGH FACING CYCLE WITH TAPER - ABOVE CENTER LINE

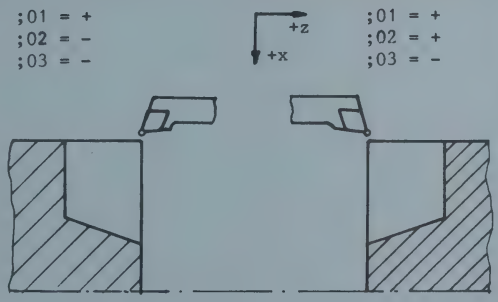
TYPICAL APPLICATION



PART PROGRAM WITH POSITIONING MOVE FOR STARTING POINT AND SUBROUTINE CALLING BLOCK(S)* INCLUDING PARAMETER VALUES.

```
ϟ
G90
G01    x37500   z165000   F00
G91
*L9900;   30000;   5000;   -3000
*L5504;;;;;;   500;;0
G90
G01   z165000   F00
ϟ
```

VARIATIONS OF SETUP BY PARAMETERS' SIGNS



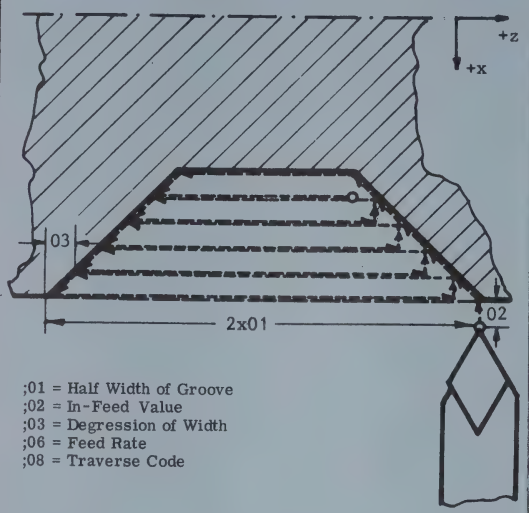
GENERAL SUBROUTINE DEFINITION

```
G25
$L55
N5501   G21   z;02   F;08
N5502   x;01;03   F;06
N5503   x;-03   z;-02
N5504   x;-01   F;08
N5505   x;03
N5506   z;02   L00
G26
```

Example 6.
L55
Rough Facing Cycle With Taper - Above Center Line

L56	GROOVING CYCLE - TAPERED, AGAINST CHUCK

TYPICAL APPLICATION

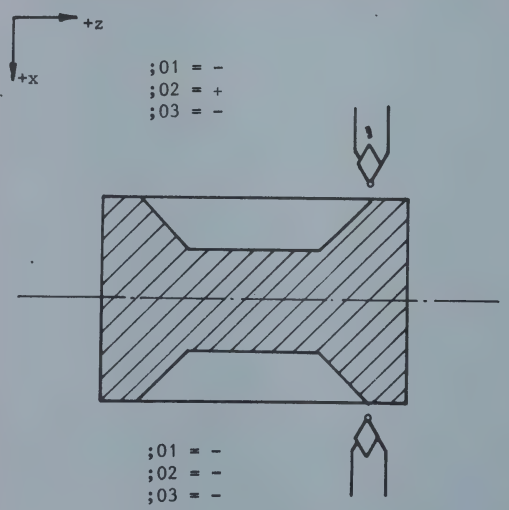


;01 = Half Width of Groove
;02 = In-Feed Value
;03 = Degression of Width
;06 = Feed Rate
;08 = Traverse Code

PART PROGRAM WITH POSITIONING MOVE FOR STARTING POINT AND SUBROUTINE CALLING BLOCK(S)* INCLUDING PARAMETER VALUES.

```
ϟ
G90
G01   x30000   z165000   F00
G91
*L9900;   -21250;-2500;   -2500
*L5605;;;;;;   500;;0
G90
G01   x30000   z165000   F00
ϟ
```

VARIATIONS OF SETUP BY PARAMETERS' SIGNS



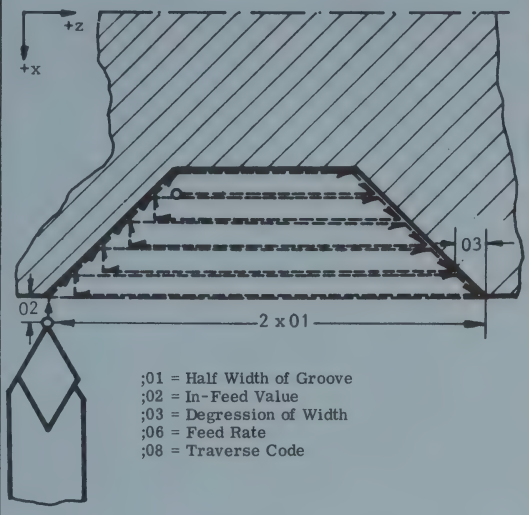
GENERAL SUBROUTINE DEFINITION

```
G25
$L56
N5601   G21   x;02   F;06
N5602   x;02   z;03
N5603   z;01;03
N5604   z;01
N5605   x;-02   z;03
N5606   z;-01   F;08
N5607   z;-01
N5608   z;-03   L00
G26
```

Example 7.
L56
Grooving Cycle - Tapered, Against Chuck

L57 GROOVING CYCLE - TAPERED, AWAY FROM CHUCK

TYPICAL APPLICATION

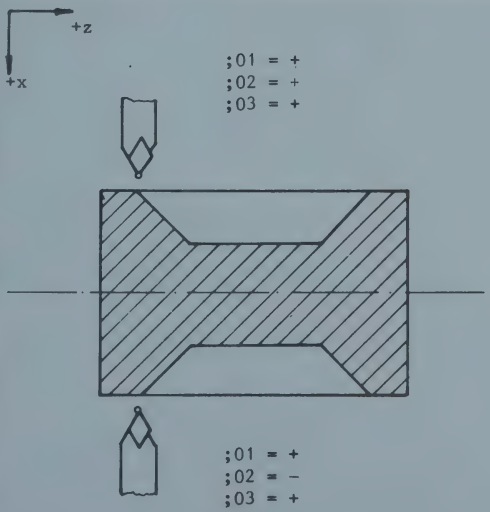


;01 = Half Width of Groove
;02 = In-Feed Value
;03 = Degression of Width
;06 = Feed Rate
;08 = Traverse Code

PART PROGRAM WITH POSITIONING MOVE FOR STARTING POINT AND SUBROUTINE CALLING BLOCK(S)* INCLUDING PARAMETER VALUES.

```
G90
G01   x30000   z122500   F00
G91
*L9900;   21250;-2500;   2500
*L5705;;;;;;   500;;0
G90
G01   x30000   z122500   F00
```

VARIATIONS OF SETUP BY PARAMETER'S SIGNS



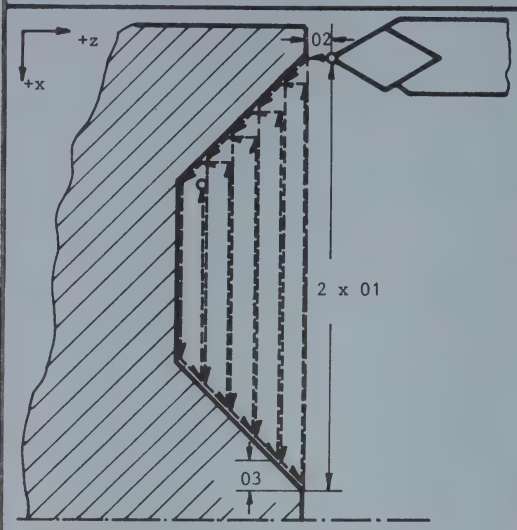
GENERAL SUBROUTINE DEFINITION

```
G25
$L57
N5701   G21   x;02   F;06
N5702   x;02   z;03
N5703   z;01;-03
N5704   z;01
N5705   x;-02   z;03
N5706   z;-01   F;08
N5707   z;-01
N5708   z;-03   L00
G26
```

Example 8.
L57
Grooving Cycle - Tapered, Away from Chuck

L58	GROOVING CYCLE - TAPERED ON A FACE, ABOVE CENTERLINE

TYPICAL APPLICATION

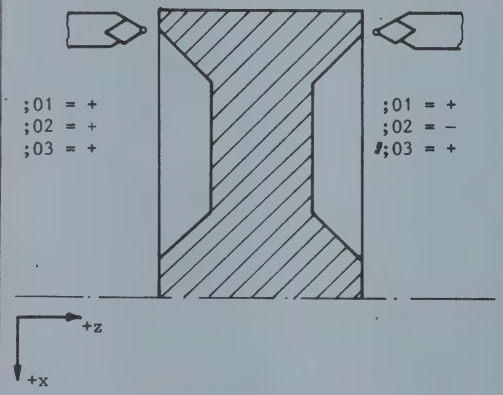


;01 = Half Width of Groove
;02 = In-Feed Value
;03 = Degression of Width
;06 = Feed Rate
;08 = Traverse Code

PART PROGRAM WITH POSITIONING MOVE FOR STARTING POINT AND SUBROUTINE CALLING BLOCK(S)* INCLUDING PARAMETER VALUES.

```
G90
G01   x-46250   z165000
G91
*L5805;   21250;-2500;   2500;;;   500;;0
G90
G01   x-46250   z165000
```

VARIATIONS OF SETUP BY PARAMETER'S SIGNS



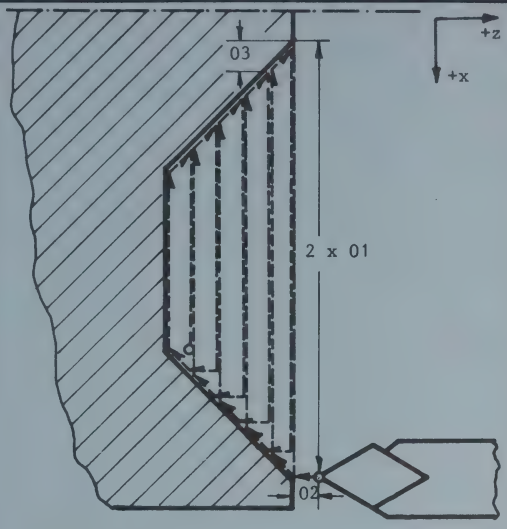
GENERAL SUBROUTINE DEFINITION

```
G25
$L58
N5801   G21   z;02   F;06
N5802   x;03   z;02
N5803   x;01;-03
N5804   x;01
N5805   x;03   z;-02
N5806   x;-01   F;08
N5807   x;-01
N5808   x;-03   L00
G26
```

Example 9.
L58
Grooving Cycle - Tapered On A Face, Above Centerline

L59	GROOVING CYCLE - TAPERED ON A FACE, BELOW CENTERLINE

TYPICAL APPLICATION

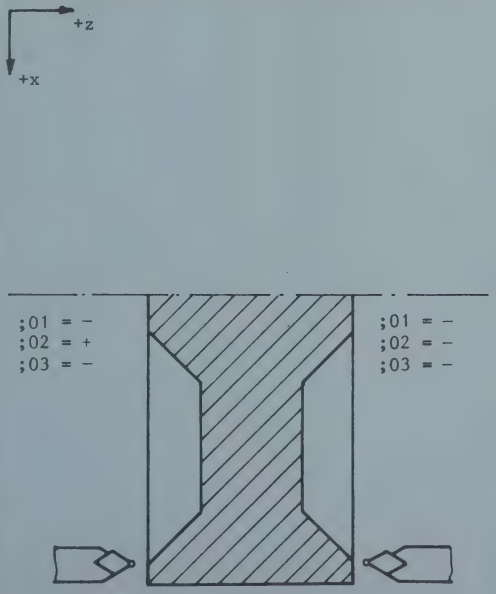


;01 = Half Width of Groove
;02 = In-Feed Value
;03 = Degression of Width
;06 = Feed Rate
;08 = Traverse Code

PART PROGRAM WITH POSITIONING MOVE FOR STARTING POINT AND SUBROUTINE CALLING BLOCK(S)* INCLUDING PARAMETER VALUES.

```
G90
G01   x46250   z165000
G91
*L5905;-21250;-2500;-2500;;;   500;;0
G90
G01   x46250   z165000
```

VARIATIONS OF SETUP BY PARAMETERS' SIGNS



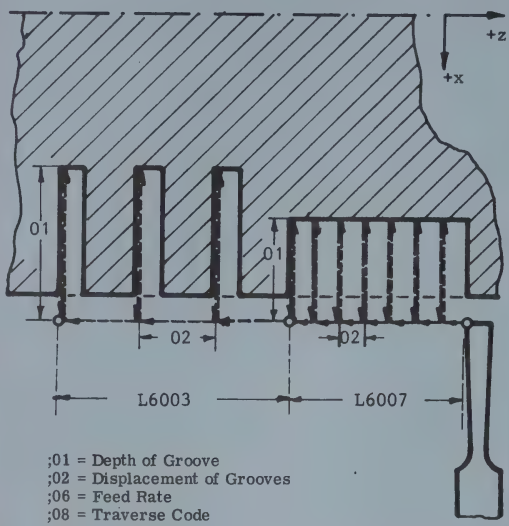
GENERAL SUBROUTINE DEFINITION

```
G25
$L59
N5901   G21   z;02   F;06
N5902   x;03   z;02
N5903   x;01;03
N5904   x;01
N5905   x;03   z;-02
N5906   x;-01   F;08
N5907   x;-01
N5908   x;-03   L00
G26
```

Example 10.
L59
Grooving Cycle - Taper On A Face, Below Centerline

L60	GROOVING CYCLE - ON A SHAFT

TYPICAL APPLICATION

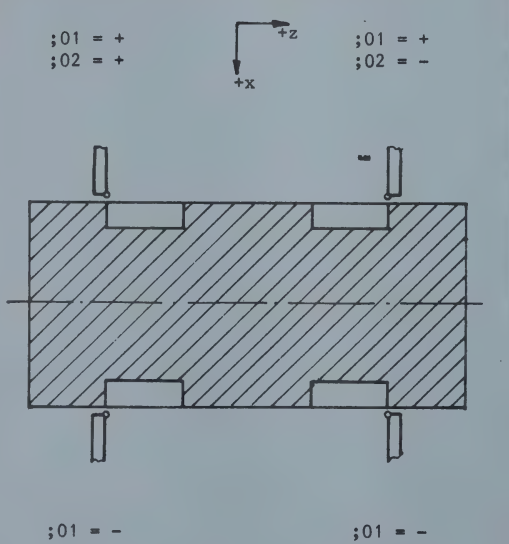


;01 = Depth of Groove
;02 = Displacement of Grooves
;06 = Feed Rate
;08 = Traverse Code

PART PROGRAM WITH POSITIONING MOVE FOR STARTING POINT AND SUBROUTINE CALLING BLOCK(S)* INCLUDING PARAMETER VALUES.

```
G90
G01   x30000   z165000   F00
G91
*L6007;   -7500;   -2500;;;;   500;;0
*L6003;-12500;-7500
G90
G01   z165000
```

VARIATIONS OF SETUP BY PARAMETERS' SIGNS



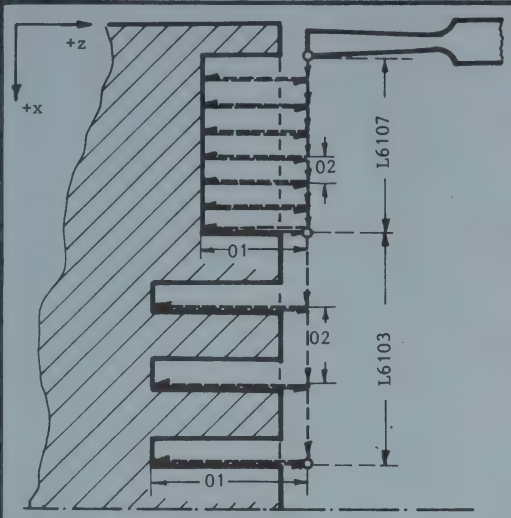
GENERAL SUBROUTINE DEFINITION

```
G25
$L60
N6001   G21   z;02   F;08
N6002   x;01   F;06
N6003   x;-01   F;08   L00
G26
```

Example 11.
L60
Grooving Cycle - On A Shaft

L61 GROOVING CYCLE - ON A FACE

TYPICAL APPLICATION

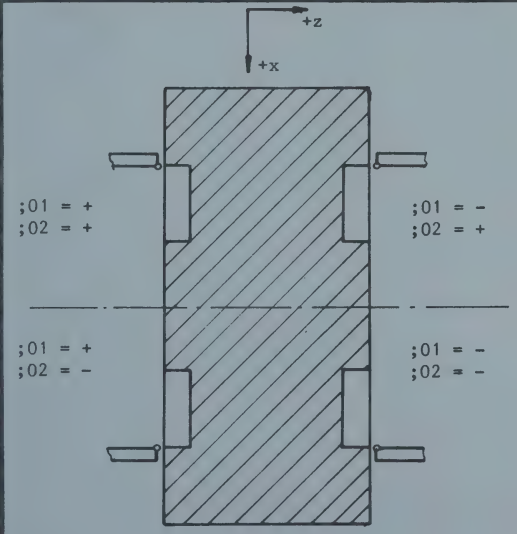


;01 = Depth of Groove
;02 = Displacement of Groove
;06 = Feed Rate
;08 = Traverse Code

PART PROGRAM WITH POSITIONING MOVE FOR STARTING POINT AND SUBROUTINE CALLING BLOCK(S)* INCLUDING PARAMETER VALUES.

```
ϟ
G90
G01   x45000   z100000
G91
*L6107;   -7500;   2500;;;;   500;;0
*L6103;-12500;   7500
G90
G01   x45000
ϟ
```

VARIATIONS OF SETUP BY PARAMETERS' SIGNS



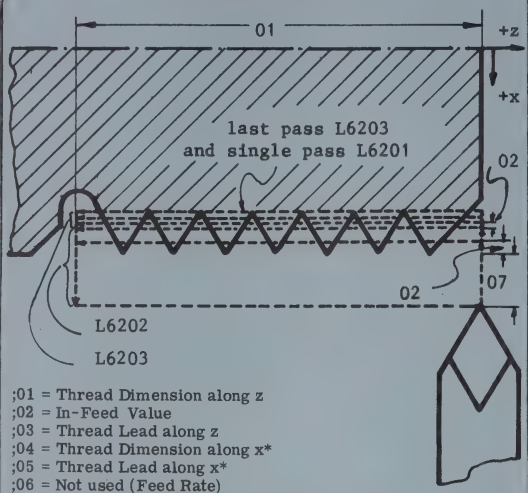
GENERAL SUBROUTINE DEFINITION

```
G25
$L61
N6101   G21   x;02   F;08
N6102   z;01   F;06
N6103   z;-01   F;08   L00
G26
```

Example 12.
L61
Grooving Cycle - On A Face

L62	LONGITUDINAL (TAPERED) THREAD, ENTRY IN X, PLUNGE FEED

TYPICAL APPLICATION



;01 = Thread Dimension along z
;02 = In-Feed Value
;03 = Thread Lead along z
;04 = Thread Dimension along x*
;05 = Thread Lead along x*
;06 = Not used (Feed Rate)
;07 = Combined In-Feed/Retract Move
;08 = Traverse Code

*Non-zero, if tapered

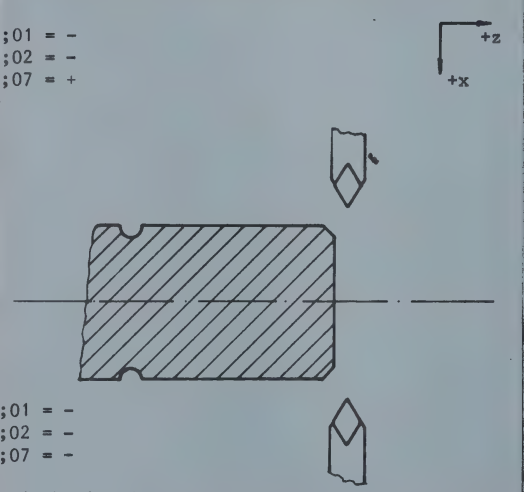
PART PROGRAM WITH POSITIONING MOVE FOR STARTING POINT AND SUBROUTINE CALLING BLOCK(S)* INCLUDING PARAMETER VALUES.

```
%
G90
x25000   z165000
G91
*L6202;-40000;-1250;5000;0;0;;-5000;0
*L6203;;-500
*L6201;;0
G90
%
```

L6202: Threading with in-feed 1.25 mm (2 passes)
L6203: Threading with in-feed 0.5 mm (3 passes)
L6201: Zero in-feed for tool relief (single pass)

VARIATIONS OF SETUP BY PARAMETERS' SIGNS

;01 = -
;02 = -
;07 = +



;01 = -
;02 = -
;07 = -

;01 should always include sufficient approach distance, which allows build-up of servo lag prior to entering the thread

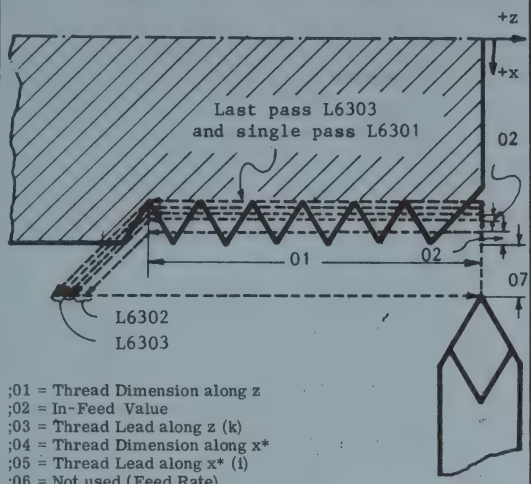
GENERAL SUBROUTINE DEFINITION

```
G25
$L62
N6201   G21   x;07;-02   F;08
N6202   G33   x;04   z;01   i;05   k;03
N6203   G01   x;-07   F;08
N6204   x;-04   z;-01   L00
G26
```

Example 13.
L62
Longitudinal (Tapered) Thread, Entry In x, Plunge Feed

L63	LONGITUDINAL (TAPERED) THREAD, PLUNGE FEED WITH RAPID PULL OUT

TYPICAL APPLICATION



;01 = Thread Dimension along z
;02 = In-Feed Value
;03 = Thread Lead along z (k)
;04 = Thread Dimension along x*
;05 = Thread Lead along x* (i)
;06 = Not used (Feed Rate)
;07 = Combined In-Feed/Retract Move
;08 = Traverse Code

*Non-zero, if tapered/pull out move 45°

PART PROGRAM WITH POSITIONING MOVE FOR STARTING POINT AND SUBROUTINE CALLING BLOCK(S)* INCLUDING PARAMETER VALUES.

```
G90
x25000  z165000
G91
*L6302;-40000;-1250;5000;0;0;;-5000;0
*L6303;;-500
*L6301;;0
```

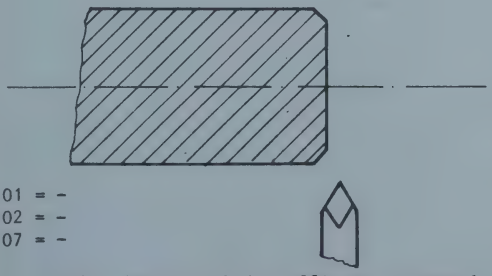
L6302: Threading with in-feed 1.25 mm (2 passes)

L6303: Threading with in-feed 0.5 mm (3 passes)

L6301: Zero in-feed for tool relief (single pass)

VARIATIONS OF SETUP BY PARAMETER'S SIGNS

No variations possible



;01 = -
;02 = -
;07 = -

;01 should always include sufficient approach distance, which allows build-up of servo lag prior to entering the thread

GENERAL SUBROUTINE DEFINITION

```
G25
$L63
N6301  G21  x;07;-02  F;08
N6302  G33  x;04  z;01  i;05  k;03
N6303  x;-07  z;07  i;03  k;03
N6304  G01  z;-07  F;08
N6305  x;-04  z;-01  L00
G26
```

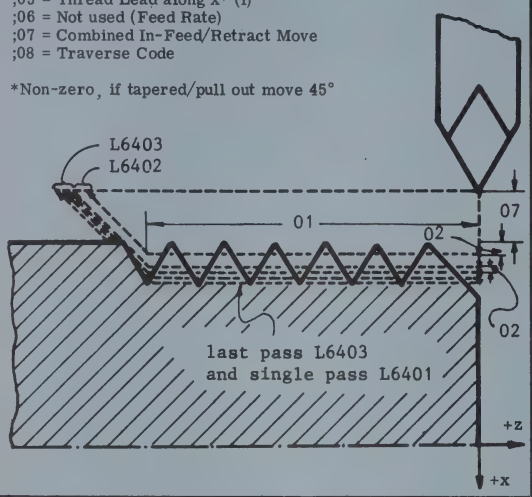
Example 14.
L63
Longitudinal (Tapered) Thread, Plunge Feed With Rapid Pull Out

L64	LONGITUDINAL (TAPERED) THREAD, PLUNGE FEED WITH RAPID PULL OUT

TYPICAL APPLICATION

;01 = Thread Dimension along z
;02 = In-Feed Value
;03 = Thread Lead along z (k)
;04 = Thread Dimension along x*
;05 = Thread Lead along x* (i)
;06 = Not used (Feed Rate)
;07 = Combined In-Feed/Retract Move
;08 = Traverse Code

*Non-zero, if tapered/pull out move 45°



PART PROGRAM WITH POSITIONING MOVE FOR STARTING POINT AND SUBROUTINE CALLING BLOCK(S)* INCLUDING PARAMETER VALUES.

```
%
G90
x25000   z165000
G91
*L6402;   -40000;   1250;5000;0;0;;5000;0
*L6403;;+500
*L6401;;   0
%
```

L6402: Threading with in-feed 1.25 mm (2 passes)

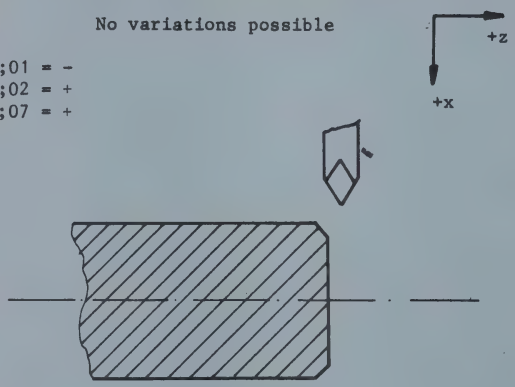
L6403: Threading with in-feed 0.5 mm (3 passes)

L6401: Zero in-feed for tool relief (single pass)

VARIATIONS OF SETUP BY PARAMETER'S SIGNS

No variations possible

;01 = -
;02 = +
;07 = +



;01 should always include sufficient approach distance, which allows build-up of servo lag prior to entering the thread

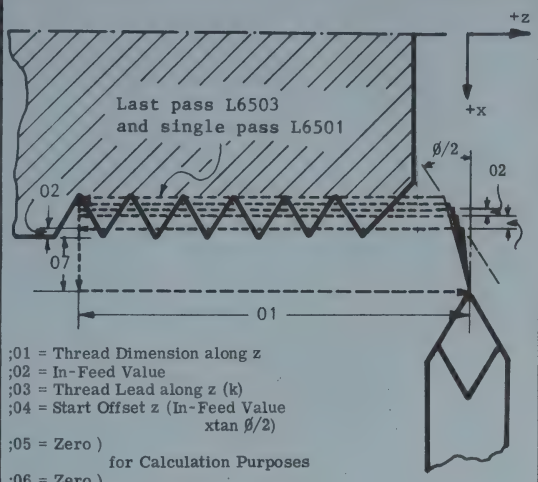
GENERAL SUBROUTINE DEFINITION

```
G25
$L64
N6401   G21   x;   07;   02   F;08
N6402   G33   x;04   z;01   i;05   k;03
N6403   x;-07   z;-07   i;03   k;03
N6404   G01   z;07   F;08
N6405   x;-04   z;-01   L00
G26
```

Example 15.
L64
Longitudinal (Tapered) Thread, Plunge Feed With Rapid Pull Out

L65	LONGITUDINAL THREAD WITH COMPOUND IN-FEED

TYPICAL APPLICATION



;01 = Thread Dimension along z
;02 = In-Feed Value
;03 = Thread Lead along z (k)
;04 = Start Offset z (In-Feed Value xtan Ø/2)
;05 = Zero) for Calculation Purposes
;06 = Zero)
;07 = Combined In-Feed/Retract Move
;08 = Traverse Code

;04 = ;02 · tan Ø/2

PART PROGRAM WITH POSITIONING MOVE FOR STARTING POINT AND SUBROUTINE CALLING BLOCK(S)* INCLUDING PARAMETER VALUES.

```
G90
x25000   z165000
G91
*L9900;-40000;-1250;5000;-722
*L6502;;;;;0;0;-5000;0
*L6503;;-500;;289
*L6501;;0;;0
```

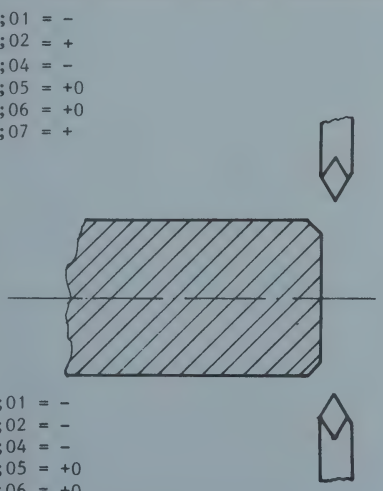
L6502: Threading with in-feed 1.25 mm (2 passes)

L6503: Threading with in-feed 0.5 mm (3 passes)

L6501: Zero in-feed for tool relief (single pass)

VARIATIONS OF SETUP BY PARAMETER'S SIGNS

;01 = –
;02 = +
;04 = –
;05 = +0
;06 = +0
;07 = +



;01 = –
;02 = –
;04 = –
;05 = +0
;06 = +0
;07 = –

;01 should always include sufficient approach distance, which allows build-up of servo lag prior to entering the thread

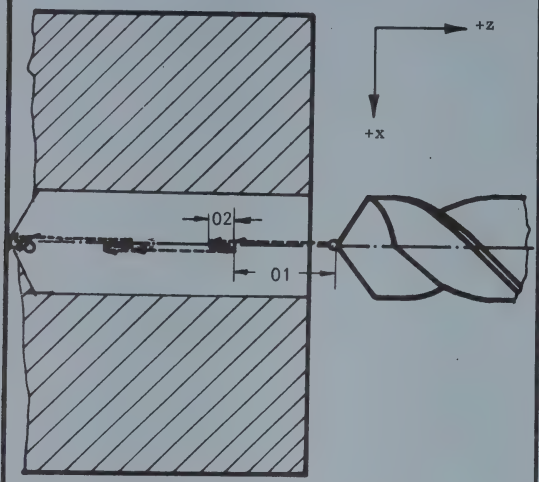
GENERAL SUBROUTINE DEFINITION

```
G25
$L65
N6501   G21   x;+07;-02   z;-06;-04   F;08
N6502   G33   z;01;-06   k;03
N6503   G21   x;-07   F;08
N6504   z;-01;06   L00
G26
```

Example 16.
L65
Longitudinal Thread With Compound In-Feed

L66	DEEP HOLE DRILLING CYCLE WITH LIFT OFF

TYPICAL APPLICATION



;01 = Depth of Hole Per Move ;06 = Feed Rate
;02 = Lift Off Value ;08 = Traverse Code

PART PROGRAM WITH POSITIONING MOVE FOR STARTING POINT AND SUBROUTINE CALLING BLOCK(S)* INCLUDING PARAMETER VALUES.

```
G90
x0   z165000   F00
G95
G91
*L6603;-10000;2500;;;;20;;0
G90
z165000   F00
```

The total depth of the hole is equal to the value of parameter #1, multiplied by the number of passes, plus parameter #02.

No variations possible.

;01 = -

;02 = +

GENERAL SUBROUTINE DEFINITION

```
G25
$L66
N6601   G01   z;01   F;06
N6602   G21   z;-02
N6603   z;02   F;08   L00
G26
```

Example 17.
L66
Deep Hole Drilling Cycle With Liftoff

SECTION 11
DETAILED OPERATION

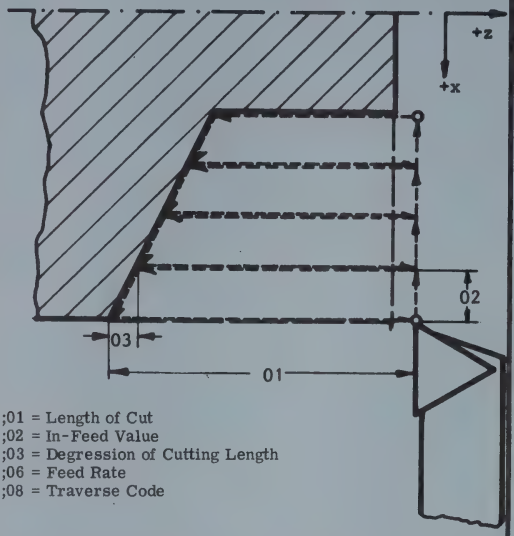
This section is for those who need or want to understand the operation of the Subroutine option in greater depth. Two of the examples shown in the examples in Section 10 are repeated on pages 36 and 38; a table on the facing page describes the operations which occur as the Control executes each block of the subroutine.

In the tables, the subroutine calls indicating the subroutine and the number of passes are shown with an asterisk. Below that are shown the individual passes which are generated by the subroutine call. The call block indicates the initial value of the parameters and the initial position of the motions.

Each succeeding block shows any parameters which are changed by that block. It also shows any move generated by that block and the resultant new position.

L51	ROUGH TURNING CYCLE WITH SHOULDER CUT TOWARDS CHUCK

TYPICAL APPLICATION

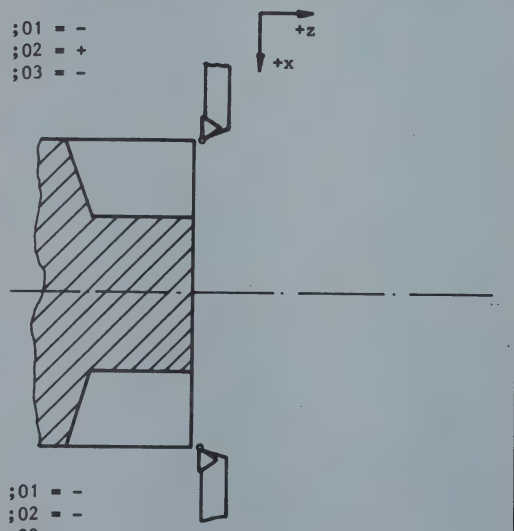


;01 = Length of Cut
;02 = In-Feed Value
;03 = Degression of Cutting Length
;06 = Feed Rate
;08 = Traverse Code

PART PROGRAM WITH POSITIONING MOVE FOR STARTING POINT AND SUBROUTINE CALLING BLOCK(S)* INCLUDING PARAMETER VALUES.

```
G90
G01   x30000   z165000   F00
G91
*L5104; -30000; -5000; -2500;;;  500;;0
G90
G01   x30000   F00
```

VARIATIONS OF SETUP BY PARAMETERS' SIGNS



GENERAL SUBROUTINE DEFINITION

```
G25
$L51
N5101   G21   x;02   F;08
N5102   z;01;03   F;06
N5103   x;-02   z;03
N5104   z;-01   F;08
N5105   z;-03
N5106   x;02   L00
G26
```

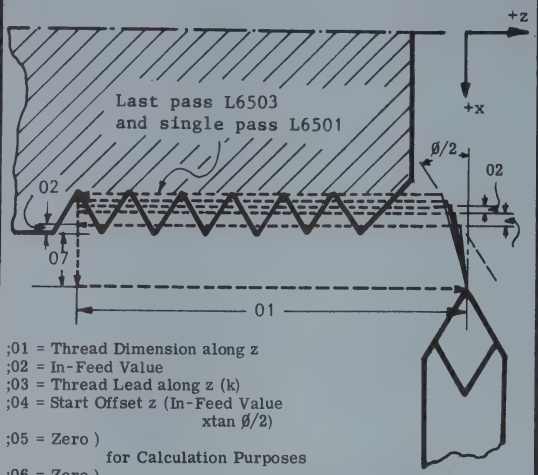
Example 2.
L51
Rough Turning Cycle With Shoulder Cut Towards Chuck

Table 2.
L51 - Rough Turning Cycle
With Shoulder Cut Towards the Chuck

Pass	PARAMETERS 1	2	3	4	5	6	7	MOTION x Move	x Position	z Move	z Position	RATE
*L5104	-30000	-5000	-2500			500			30000		165000	
1												
N5101								-5000	25000			Traverse
N5102	-27500									-27500	137500	500
N5103								+5000	30000	-2500	135000	500
N5104										+27500	162500	Traverse
N5105										+2500	165000	Traverse
N5106								-5000	25000			Traverse
2												
N5101								-5000	20000			Traverse
N5102	-25000									-25000	140000	5000
N5103								+5000	25000	-2500	137500	5000
N5104										+25000	162500	Traverse
N5105										+2500	165000	Traverse
N5106								-5000	20000			Traverse
3												
N5101								-5000	15000			Traverse
N5102	-22500									-22500	142500	5000
N5103								+5000	20000	-2500	140000	5000
N5104										+22500	162500	Traverse
N5105										+2500	165000	Traverse
N5106								-5000	15000			Traverse
4												
N5101								-5000	10000			Traverse
N5102	-20000									-20000	145000	5000
N5103								+5000	15000	-2500	142500	5000
N5104										+20000	162500	Traverse
N5105										+2500	165000	Traverse
N5106								-5000	10000			Traverse

• L65 — LONGITUDINAL THREAD WITH COMPOUND IN-FEED

TYPICAL APPLICATION



;01 = Thread Dimension along z
;02 = In-Feed Value
;03 = Thread Lead along z (k)
;04 = Start Offset z (In-Feed Value xtan Ø/2)
;05 = Zero) for Calculation Purposes
;06 = Zero)
;07 = Combined In-Feed/Retract Move
;08 = Traverse Code

;04 = ;02 · tan Ø/2

PART PROGRAM WITH POSITIONING MOVE FOR STARTING POINT AND SUBROUTINE CALLING BLOCK(S)* INCLUDING PARAMETER VALUES.

```
G90
x25000  z165000
G91
*L9900;-40000;-1250;5000;-722
*L6502;;;;;0;0;-5000;0
*L6503;;-500;;289
*L6501;;0;;0
```

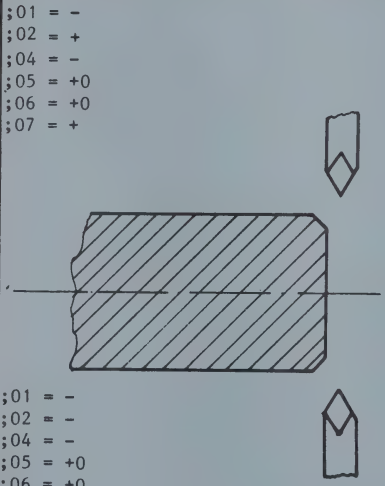
L6502: Threading with in-feed 1.25 mm (2 passes)

L6503: Threading with in-feed 0.5 mm (3 passes)

L6501: Zero in-feed for tool relief (single pass)

VARIATIONS OF SETUP BY PARAMETER'S SIGNS

;01 = –
;02 = +
;04 = –
;05 = +0
;06 = +0
;07 = +



;01 = –
;02 = –
;04 = –
;05 = +0
;06 = +0
;07 = –

;01 should always include sufficient approach distance, which allows build-up of servo lag prior to entering the thread

GENERAL SUBROUTINE DEFINITION

```
G25
$L65
N6501  G21  x;+07;-02  z;-06;-04  F;08
N6502  G33  z;01;-06  k;03
N6503  G21  x;-07  F;08
N6504  z;-01;06  L00
G26
```

Example 16.
L65
Longitudinal Thread With Compound In-Feed

Table 3.
L65 - Longitudinal Thread
With Compound In-Feed

Pass	PARAMETERS 1	2	3	4	5	6	7	MOTION x Move	x Position	z Move	z Position	RATE
*L6502	-40000	-1250	5000	-722	0	0	-5000		25000		165000	
1												
N6501						722	-6250	-6250	18750	-722	164278	Traverse
N6502	-39278									-39278	125000	Threadcut
N6503								+6250	25000			Traverse
N6504	-40000									+40000	165000	Traverse
2												
N6501						1444	-7500	-7500	17500	-1444	163556	Traverse
N6502	-38556									-38556	125000	Threadcut
N6503								+7500	25000			Traverse
N6504	-40000									+40000	165000	Traverse
*L6503		-500		-289								
1												
N6501						1733	-8000	-8000	17000	-1733	163267	Traverse
N6502	-38267									-38267	125000	Threadcut
N6503								+8000	25000			Traverse
N6504	-40000									+40000	165000	Traverse
2												
N6501						2022	-8500	-8500	16500	-2022	162978	Traverse
N6502	-37978									-37978	125000	Threadcut
N6503								+8500	25000			Traverse
N6504	-40000									+40000	165000	Traverse
3												
N6501						2311	-9000	-9000	16000	-2311	162689	Traverse
N6502	-37689									-37689	125000	Threadcut
N6503								+9000	25000			Traverse
N6504	-40000									+40000	165000	Traverse
*L6501		0		0								
N6501						2311	-9000	-9000	16000	-2311	162689	Traverse
N6502	-37689									-37689	125000	Threadcut
N6503								+9000	25000			Traverse
N6504	-40000									+40000	165000	Traverse

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CHAPTER V
MACHINE INTERFACE

MACHINE INTERFACE

Section 1 summarizes machine interface connections which are standard or provided with options other than programmable interface. All of these connections are made at the customer's terminal board panel. Complete wiring is shown in reference sheets 900-914 of the elementary diagrams (GEK-25295).

Section 2 describes the standard option for m, s and t BCD outputs.

Section 3 will describe the Programmable Machine Interface option. It will be provided later.

SECTION 1
SUMMARY OF CUSTOMER CONNECTIONS

CUSTOMER INPUTS TO CONTROL

Customer inputs to the Control are given below.

Remote Control Station Devices

Jog pushbuttons

Feedhold pushbutton (normally closed - open for feedhold)

Stop pushbutton

Jog selector switch (wired for 3 bit gray-coded switch. A straight selector switch may be used by adding diodes - see the connection diagrams, GEK-25268.

Remote/Console switch

Cycle Start pushbutton

MFO potentiometer

Mode selector switch Manual/Auto/Single

Automatic Cycle Start switch

Interlocks

Control on

Permit transfer and cycle start (closes to permit)

Motion inhibit (opens to inhibit)

Servo fault (opens for fault)

Disable spindle speed monitor (closes to disable)

Limit Switches

Overtravel - 2 per axis

Reference zero - 1 per axis - opens at zero

Miscellaneous

Input from feedback device (resolver or Inductosyn*)

Threadcutting encoder (resolver)

Spindle speed gear range selections (option)

Tachometer (hydraulic option)

CONTROL OUTPUTS TO CUSTOMER

Customer outputs are listed below.

Buses

+25V present when incoming power is applied

-12V for switched inputs to the Control

+12V, -12V } for Inductosyn* excitation

+5.7V for lights

Relay Contacts

Control on (1 normally open)

Loop relay (1 normally open, 1 normally closed)

Emergency Stop (1 Form C)

*Registered trademark of Farrand Controls, Inc.

Output Driver Outputs

Manual mode

m00/m02/m30 (152 millisecond output)

m01 (152 millisecond output when validated by Option Stop being lit)

Spindle clockwise (m03)

Spindle counterclockwise (m04)

Clear

Feedhold

Cycle start

x axis lube

z axis lube

Switch Contact

Test mode (switches to ground)

Analog Outputs

Position loop amplifier output - 1 per axis

D/A spindle output

Feedback device excitation

Spindle resolver excitation

Hydraulic valve panel (option)

SECTION 2
STANDARD BCD OUTPUT MACHINE INTERFACE

With this option, the following outputs are provided:

m 2 digits of BCD

m Strobe

s 3 digits of BCD - first 3 digits of s word

s Strobe

t 2 digits of BCD - first 2 digits of t word

t Strobe

The signal name of each BCD output contains the digit followed by a decimal point and then the weight of the bit in that digit. For example, the output, $\overline{MA1.8OD}$ refers to digit 1 and the bit with a weight of 8. The signal name is barred because the active state of the output is low.

Outputs are rated 250 ma and 25VDC maximum.

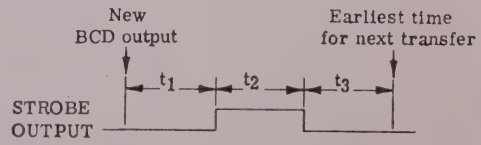
If zeros are programmed in both of the first two t digits, no t strobe is produced.

Strobe Timing

When an m, s or t function becomes active, the new BCD outputs appear and remain until changed or cleared. M00, m02, m30 and m01 do not become active until the completion of any commanded motion. All other functions become active when the block containing them becomes active.

As shown in the sketch below, the strobe outputs are delayed for a time, t_1, after the BCD outputs appear. The strobe time is t_2. Following the strobe, the next transfer cannot occur until after a delay, t_3.

The delay times t_1 and t_3 are equal and are selected by Machine Setup Data. The strobe time t_2 is also selected by Machine Setup Data. The selected times may be any value, which is divisible by 4 from 0 to 996 milliseconds. The selected times are minimums and may be longer if the processor is loaded.



CHAPTER VI
INTERPRETATION OF LOGIC DIAGRAMS

GEK-45677

INTERPRETATION OF THE LOGIC DIAGRAMS FOR 1050 SERIES CONTROLS

October, 1977

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INTERPRETATION OF THE LOGIC DIAGRAMS

SECTION 1
CONTROL NUMBER SYSTEM AND CONTROL LOGIC

The number system and basic logic used by the Control are described below.

NUMBER SYSTEM USED BY THE CONTROL

The Control uses the binary system of counting -- it uses only two digits, "0" and "1". When it has to go past 1 in the binary system, the Control does just what we do when we have to go past 9 in the decimal system; i.e., it starts using the digits over again in combination.

In the Control system, each binary 1 (also called "logic" 1) represents approximately +3.8 volts, and each binary 0 (also called "logic" 0) represents 0 volts. The 0-volt bus (ground) is the reference for these voltages.

The conversion of a large number into binary notation could become quite cumbersome, and recognition of such a number could be exceedingly difficult. Consequently, the hexadecimal system is used.

Hexadecimal

A hexadecimal system is one with a base of 16. Each hexadecimal digit can have a value from 0 to F. The table below shows the 16 hexadecimal values and the corresponding notation in binary and decimal systems.

Hexadecimal	Binary	Decimal
0	0000	0
1	0001	1
2	0010	2
3	0011	3
4	0100	4
5	0101	5
6	0110	6
7	0111	7
8	1000	8
9	1001	9
A	1010	10
B	1011	11
C	1100	12
D	1101	13
E	1110	14
F	1111	15

The Control uses 16-bit words which are commonly expressed by 4-digit hex words. The largest 4-digit hex word is FFFF corresponding to 1111111111111111 in binary and 65,535 in decimal.

Binary Coded Decimal

Binary coded decimal outputs are sometimes used for the m, s or t outputs to the customer.

A binarily coded decimal digit is simply a decimal digit expressed in four-place binary notation. If the particular decimal digit is small enough to be expressed in fewer than four binary places, the "left-over" binary places are filled in with zeros. For example, decimal 5 converted to binary, becomes 101. Decimal 5 expressed in BCD, however, is 0101.

The two-place decimal 19 is written in BCD as follows:

1	9	(decimal)
0001	1001	(BCD)

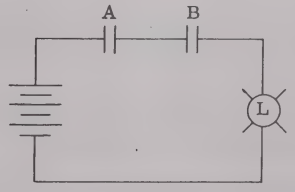
Notice that we have binarily coded each decimal digit using four binary digits for each decimal digit.

CONTROL LOGIC

Basic logic is used by the Control to "decide" what to do and when to do it. This logic, which has been formalized by means of Boolean Algebra, is used to depict the circuits throughout the Control. Two basic logic functions can be performed: AND and OR.

"AND" Function

For demonstration purposes, let us consider a very simple logic circuit:



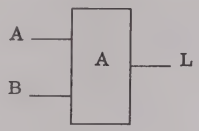
This circuit is called an AND circuit. According to this circuit, the light turns on if relay A is energized and if, simultaneously, relay B is energized.

"A" stands for "Relay A is energized".

"B" stands for "Relay B is energized".

In Boolean Algebra, we would write the equation A• B = L. The dot (•) symbol is used to mean "AND simultaneously".

The circuit symbol which represents this Boolean equation, is:



This is called an AND gate or an AND function.

Now, if we use logic 1 to mean "True" and logic 0 to mean "False", we can write a table for all of the possible conditions for our circuit, as follows:

A	B	L
0	0	0
0	1	0
1	0	0
1	1	1

This is called a "Truth Table". It is the Truth Table for an AND gate.

In effect, it states:

1. It is false that relay A is energized and, simultaneously, it is false that relay B is energized. Therefore, it is false that the light turns on.

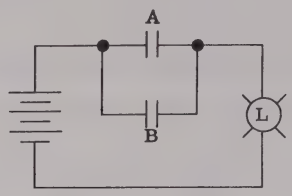
2. It is false that relay A is energized and, simultaneously, it is true that relay B is energized. Therefore, it is false that the light turns on.

3. It is true that relay A is energized and, simultaneously, it is false that relay B is energized. Therefore, it is false that the light turns on.

4. It is true that relay A is energized and, simultaneously, it is true that relay B is energized. Therefore, it is true that the light is on.

"OR" Function

Now let us consider another simple logic circuit.



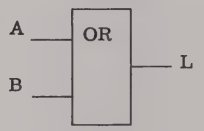
According to this circuit, the light turns on if relay A is energized or if relay B is energized, or if they are both energized.

"A" stands for "Relay A is energized."

"B" stands for "Relay B is energized."

In Boolean Algebra, then, we would write the equation A + B = L. The symbol "+" is used to mean "OR". This "OR" is an "inclusive OR", i.e., the output is dependent upon either one of the two inputs, or upon both inputs. (In other words, in our example, output L is dependent on input A, or on input B, or on inputs A and B.)

The circuit symbol which represents the Boolean equation is:



This is called an OR gate or an OR function.

Now, if we use logic 1 to mean "True" and logic 0 to mean "False", we can write a table for all of the possible conditions for our circuit, as follows:

A	B	L
0	0	0
0	1	1
1	0	1
1	1	1

Ref. 57-02
57-03
57-04
57-05
57-06

The above Truth Table for the OR gate states:

1. It is false that relay A is energized and, simultaneously, it is false that relay B is energized. Therefore, it is false that the light turns on.

2. It is false that relay A is energized and, simultaneously, it is true that relay B is energized. Therefore, it is true that the light turns on.

3. It is true that relay A is energized and, simultaneously, it is false that relay B is energized. Therefore, it is true that the light turns on.

4. It is true that relay A is energized and, simultaneously, it is true that relay B is energized. Therefore, it is true that the light is on.

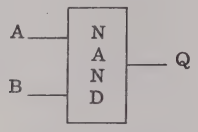
Boolean Algebra is a powerful tool in circuit design. Its application to the various circuits in the Control system is described in the following section.

SECTION 2
LOGIC ELEMENTS AND THEIR SYMBOLS

There are many types of logic elements used in the Control. Some of these may perform the simple AND and OR functions described in the previous section. Some are bistable elements which perform the memory function. Others are combinations of the above, with the more complex elements comprising a thousand or more of the simple functions.

In this section, the types of logic elements used in the Control will be described. Complete symbol information for specific logic elements is part of the set of diagrams for the printed-circuit boards.

The most common gate element used in the Control is a NAND gate which is an inverting type of gate in the form of a solid-state, transistorized switch. The diagram of a NAND gate and the truth table for it are shown below.



A	B	Q
0	0	1
0	1	1
1	0	1
1	1	0

The NAND gate can best be understood when it is considered in terms of AND, OR and INVERTER functions.

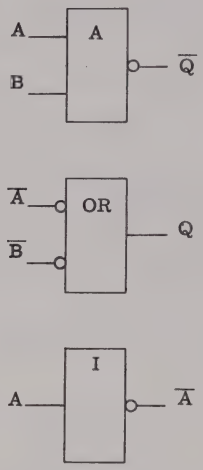
We may think of the NAND gate as an AND or an OR if we remember that the output of the gate must be inverted when an AND function is required and that its inputs must be inverted when an OR function is required. Small circles are appropriately placed at the connection point on the logic symbols used in the Elementary Diagrams to remind us that inversion is necessary.

The NAND gate has three uses:

1. As an AND Gate
2. As an OR Gate
3. As an INVERTER

In order for the NAND gate to be used as an AND gate, its output must be inverted; in order for it to be used as an OR gate, any of its inputs which are to be ORed, must be inverted; and in order for it to be used as an INVERTER, all inputs but one are permanently connected to a logic 1 signal or all inputs may be paralleled. Henceforth, instead of referring to these gates as NAND gates, we will refer to them in accordance with the way in which they are used. Thus, the NAND gate whose outputs are inverted will be called an AND gate; the NAND gate whose inputs which are to be ORed are inverted, will be called an OR gate; and the NAND gate having only one input connected to a logic signal, will be called an INVERTER.

The logic symbols for the NAND used as an AND gate, OR gate and INVERTER are as follows:



The preceding diagrams are interpreted as follows:

AND gate: A and B produce an output "Not Q". The Boolean expression for this function is:

$$A \cdot B = \overline{Q}$$

OR gate: "Not A" or "Not B" produces an output, Q. The Boolean expression for this function is:

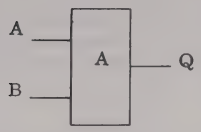
$$\overline{A} + \overline{B} = Q$$

Inverter: A logic 1 at the input produces a logic 0 at its output. A logic 0 at its input becomes a logic 1 at its output.

AND Gate

There are some true AND gates used which are non-inverting. The truth table and symbol are given below. The Boolean expression is:

$$A \cdot B = Q$$

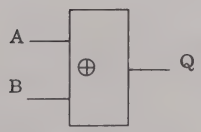


A	B	Q
0	0	0
0	1	0
1	0	0
1	1	1

Exclusive OR

As shown in the truth table below when the inputs to the Exclusive OR gate are unlike, the output is logic 1. Conversely, when the inputs are alike, the output is logic 0. The Boolean expression for this function is:

$$Q = A \cdot \overline{B} + \overline{A} \cdot B$$



A	B	Q
0	0	0
0	1	1
1	0	1
1	1	0

POSITIVE LOGIC

In the 1050 Controls, positive-level logic is used. That is, a signal at logic 1 is positive with respect to a signal at logic 0. The actual voltages associated with logic levels in the Control are as shown in the table below.

LOGIC LEVEL	VOLTAGE LEVEL
1	+2.4 to 5 volts
0	0 to 0.4 volts

Normally, using NAND gates, the sequence of logic circuits is AND-OR-AND. When an OR gate is connected directly to a preceding AND gate, its inputs are not inverted because the output of the AND gate is already inverted.

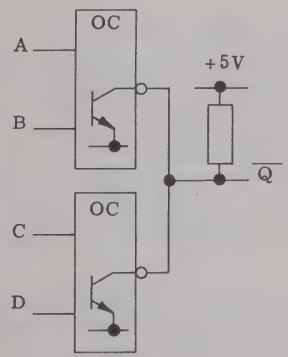
To invert the signal to the input of each OR gate which is not preceded by an AND gate, the proper signal is selected if it is available. If the proper signal is not available, a separate inverter is used.

OPEN-COLLECTOR GATE

A type of gate element called an "open-collector"gate may be used expressly as a wired-OR circuit. That is, the outputs may be connected without the inputs likewise being paralleled. This connection is possible because of the output circuit of the gate element. It consists of only an open, uncommitted collector of a transistor, and must rely on external circuits for its pull-up network when the gate output is to be at a logic 1. Hence, external pull-up resistors are utilized for this purpose.

An open-collector circuit is shown in the figure below. The gate symbol includes the letters OC but not the transistors which are drawn here only for clarity.

Notice that either (or any) gate output can pull the output to a logic 0 but both (or all) must be off in order for the output to be a logic 1. This wire-tied output may be driven by several sources and may drive several loads.



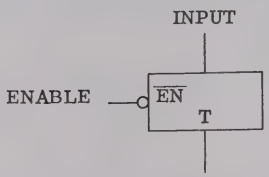
Ref. 57-09
57-10
57-11

THREE-STATE OUTPUTS

Some elements are designed to have 3 distinct output states. They act as normal elements with logic 1 and logic 0 outputs, as long as an enable control input is in the enable condition. If the enable control input is in the disable condition, the output is in the third state in which it exhibits a high impedance.

Three-state outputs are used as bus drivers and generally a number of them will be connected to a bus. It is necessary that only one three-state driver be enabled at one time to one bus. If it is desirable to have the output to logic 1 when all drivers are disabled, a pull-up resistor must be added to the bus.

Three-state outputs are denoted by the letter T at the output. The circle at the enable input denotes a logic 0 will enable.



FAMILIES OF LOGIC ELEMENTS

Several series of logic elements are used in order to optimize performance. Most of these are in the transistor-transistor-logic (TTL) family and include "standard" TTL, the "H" series which provide a higher fan-out, the Schottky series which provides higher speed and the low-power Schottky which is medium speed and has low power consumption. These are all compatible and employ the same symbols, differing only in the identification number.

Another family which has limited use in the Control is the complimentary metal-oxide-semiconductor (CMOS). These are a very low power type and much slower. Similar logic symbols are used but CMOS elements have the letters CM in the symbol.

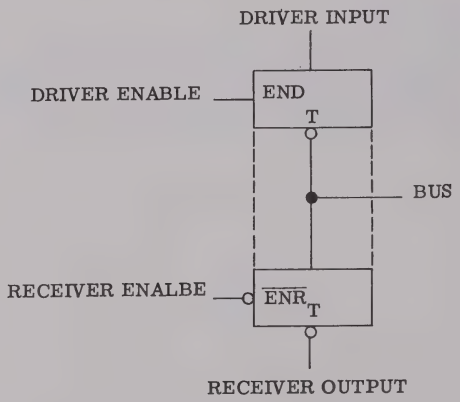
A few of the large scale integration (LSI) chips are of metal-oxide-semiconductor (MOS) type. These have outputs designed to interface TTL.

DRIVERS AND DRIVER/RECEIVERS

A number of elements are used whose function is to provide the power boost or voltage boost necessary to drive a bus or a special circuit. These drivers are similar to gates or inverters, and most of them have similar symbols. The exceptions include the bus driver/receiver, the line-driver and line receiver for RS-232C interface, and the MOS clock driver.

Bus Driver/Receiver

This element provides the interface between the printed-circuit boards and the backplane busses. The driver or receiver may be enabled by its respective control enable lines which are common to all 4 elements on the package.

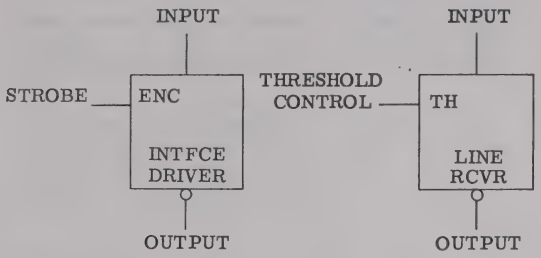


Interface Line Driver and Receiver

A special line driver and special line receiver are used to interface to signals defined by RS-232. These logic elements provide the conversion from the Control's logic levels to the logic levels specified by RS-232.

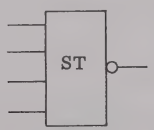
The driver has a common strobe input for both elements on the package.

The receiver has a threshold control which has been connected to +5V to improve noise margin for receivers which always have the input connected. The threshold control has been left disconnected for receivers where the input may be floating.



SCHMITT TRIGGERS

These Schmitt-Trigger circuits are similar to 4-input NAND gates except that they have different input threshold levels for positive and negative-going signals. The hysteresis or backlash which is the difference between the two levels is 400 mv minimum. They can have very slow rising input ramps and still give clean jitter free output signals.



FLIP-FLOPS

A flip-flop is called a "memory" element because of its ability to retain its state until it receives a signal to change it. The name of a flip-flop is the same as the name of its Set output. The name of the Clear side of the flip-flop is exactly the same as that of the Set side except that it is barred. That is, the name has a line over it.

The name is true when there is a logic 1 on the wire; it is false when there is a logic 0 on the wire. Let us take the names F1 and $\overline{F1}$, for example. A wire labeled F1 is logic 1 when flip-flop F1 is set and is logic 0 when F1 is cleared. The wire labeled $\overline{F1}$ is logic 0 when the flip-flop F1 is set is logic 1 when F1 is cleared.

If a flip-flop is set, it will produce a logic 1 signal at its Set output and a logic 0 signal at its Clear output. The flip-flop remains "set" until cleared, whereupon a logic 0 appears at its Set output and a logic 1 appears at its Clear output.

A flip-flop can be set in either of two ways:

1. Through the use of its DC Set input. A circle at this input indicates a logic 0 input will set.

2. Through the combination of its Set Steering inputs and its Trigger input. (Any flip-flop which is set in this way is called a "steered" flip-flop).

The flip-flop can be cleared in either of two ways:

1. Through the use of the DC Clear input.

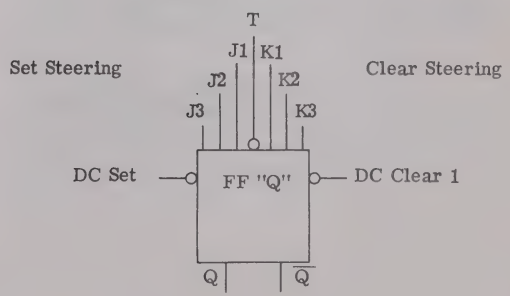
2. Through the combination of its Clear steering inputs and its Trigger input.

The flip-flop is triggered by the transition of the trigger signal from logic 1 to logic 0.

If we have a flip-flop in its Clear state and we wish to cause it to set, steering signals at the logic 1 level must be applied before the trigger goes to a logic 0 state. The flip-flop changes state when the trigger goes negative.

The flip-flop most commonly used in the Control is a J-K flip-flop. In other words, it has a common trigger, so that it resets and sets alternately. The logic symbol for one of the J-K flip-flops is shown. The inversion symbol (small circle) at the trigger input shows that, to trigger the flip-flop, the input must go from a logic 1 to a logic 0.

For the flip-flops shown, all 3 set steering inputs must be at logic 1 to permit the flip-flop to set with the trigger. Likewise all 3 clear steering inputs are required for the trigger to clear the flip-flop.



Ref. 57-14
57-15
57-16
57-17

DUAL RETRIGGERABLE ONE-SHOT

This circuit element functions like a flip-flop which remains set when its input conditions are satisfied and cleared when they are not.

When the retriggerable one-shot is used to detect the presence of a recurring pulse, such as for loss-of-clock or loss-of-feedback detection, the following must be true:

1. $\overline{\text{INPUT}}$ is logic 0 and INPUT is toggling at a frequency whose period is less than approximately 0.3RC which is established by the external timing circuit.

-OR-

2. INPUT is logic 1 and $\overline{\text{INPUT}}$ is toggling as in No. 1 above.

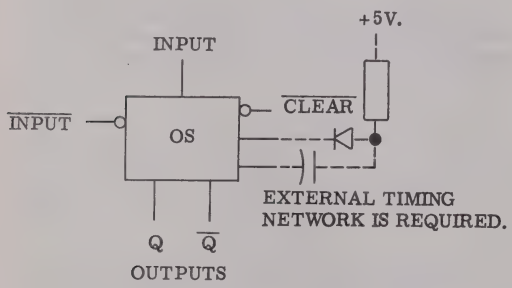
-OR-

3. Alternate operation of 1 or 2 above.

When used as a timer, such as to block pushbutton contact bounce, the retriggerable one-shot operates as follows:

1. When $\overline{\text{INPUT}}$ is logic 0 and INPUT goes from 0 to 1, the one-shot sets and remains set for a period equal to approximately 0.3RC, after which the one-shot clears.

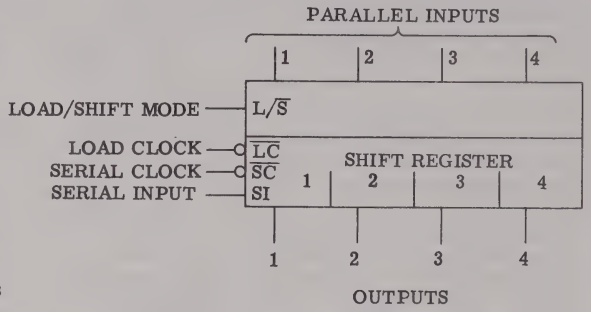
2. When INPUT is logic 1 and $\overline{\text{INPUT}}$ goes from 1 to 0, the one-shot sets and remains set for a period equal to approximately 0.3RC, after which the one-shot clears.



SHIFT REGISTERS

A shift register consists of a number of flip-flops connected in a serial string so as to allow data to be shifted along the string of flip-flops.

Shift register operation will be explained using the 4-bit shift register which is shown. This is the most commonly used shift register in the Control.



SYMBOL FOR 4-BIT SHIFT REGISTER

This shift register has both a Parallel Load mode and a Serial mode.

Parallel Load Mode

If the mode control is logic 1, the Load mode (Parallel Load) is selected and with a negative transition of the load clocks, each of the 4 flip-flops will store the logic state of its input. The output of each flip-flop will now correspond to that state.

Shift Right Mode

If the mode control input is logic 0, the shift mode is selected. At the negative transition of the serial clock, the logic state of the serial input is transferred to flip-flop 1. Each of the other flip-flops goes to the state that the flip-flop to its left had prior to the clocks transition.

Shift Left Mode

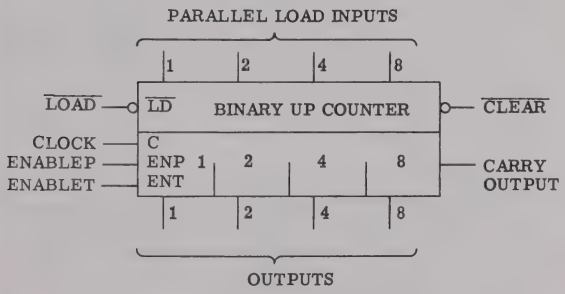
This shift register can be connected for a shift left operation by connecting the outputs of 4, 3 and 2 to the inputs of 3, 2 and 1 respectively and using the input of 4 as a serial input. The shift register is then operated as in the Parallel Load mode.

8-Bit Shift Registers

One type of 8-bit shift registers has only a serial input and an output from the right-most bit (serial in, serial out). Another has a Parallel Load but only a serial output (parallel in, serial out). A third is a serial in, parallel out. Shift registers with more than 8 bits are serial in, serial out.

COUNTERS

A synchronous, presettable, 4-bit binary up counter is shown below.



Counting

Synchronous operation is provided by having all flip-flops clocked simultaneously so that the outputs change coincident with each other when so instructed by the count-enable inputs and internal gating. A buffered clock input triggers the 4 flip-flops on the rising (positive-going) edge of the clock input waveform.

Parallel Load

These counters are fully programmable; that is, the outputs may be preset to either level. As presetting is synchronous, setting up a logic 0 at the load input disables the counter and causes the outputs to agree with the load inputs after the next clock pulse regardless of the levels of the enable inputs.

Clear

The clear function is synchronous and a low level (logic 0) at the clear input clears all 4 of the flip-flop outputs to logic 0 after the next clock pulse, regardless of the levels of the enable inputs. This synchronous clear allows the count length to be modified easily as decoding the maximum count desired can be accomplished with one external NAND gate. The gate output is connected to the clear input to synchronously clear the counter to 0000.

Carry Output

The carry look-ahead circuitry provides for cascading counters for n-bit synchronous applications without additional gating. Instrumental in accomplishing this function are 2 count-enable inputs and a carry output. Both count-enable inputs (P and T) must be high to count, and input T is fed forward to enable the carry output. The carry output thus enabled will produce a positive output pulse with a duration approximately equal to the positive portion of the first flip-flop's output. This positive overflow carry pulse can be used to enable successive cascaded stages.

Other Counters

Other counters which are used will be identified in the symbol sheets which accompany the board diagrams. A brief description of these follows.

A ripple counter differs from a synchronous counter in that the change in output states ripples through, with the change of the first output changing the second etc.

Another type of counter is a decimal counter. The decimal counter has a count sequence which after reaching 9 goes back to 0. This contrasts with the binary counters which have a sequence that reaches 15 before "rolling over" to 0.

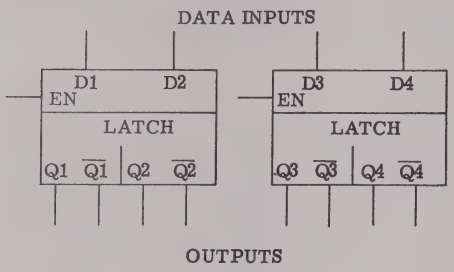
Yet another type is the up-down counter in which the count can be made to increase or decrease by choice of logic level on the up/down control input.

LATCHES

Latches are simple flip-flops (memory elements) which can be used for storage.

4-Bit Latch

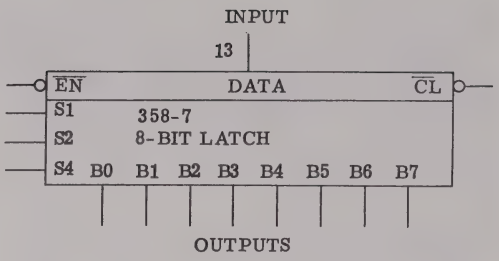
A 4-bit latch package has separate enables for each 2 of the bits as shown. When the enable input is high, the Q output will follow the corresponding D input. When the enable input goes low, the data present at D at the time of transition is retained at Q.



8-Bit Addressable Latch

The data input at the single input line is transferred to the output of the addressed bit when the enable input is logic 0. The table below gives the address for each bit. When the enable line goes to logic 1 or the address is changed from a particular bit, the output at that bit will be retained if the clear input is left high.

If the clear and enable inputs are both logic 0 and the data input is logic 1, the addressed bit only will have a logic 1 output and all other bits will be logic 0.



Address Table			
SB	S2	S1	Bit
0	0	0	B0
0	0	1	B1
0	1	0	B2
0	1	1	B3
1	0	0	B4
1	0	1	B5
1	1	0	B6
1	1	1	B7

MEMORIES

The term memory refers to the elements where data is stored. Flip-flops, shift registers, latches and counters, which have already been described, are forms of memory although generally the term memory is applied to larger arrays.

Types of Memories

All memories must have a means of addressing every location and a means of determining the binary digit stored at that location.

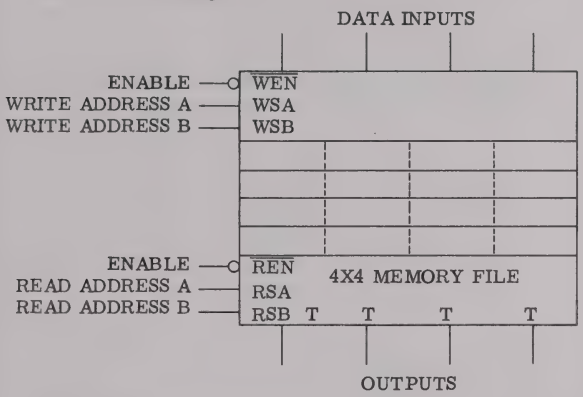
A memory in which the data can be read but cannot be altered is called a Read-Only memory (ROM). A special form of ROM is the Programmable Read-Only Memory (PROM) which will be described later.

A memory in which data can be altered (written) as well as read is called a read/write memory. Read/write memories are commonly called Random Access Memories (RAM).

RAM's can be further classified as static or dynamic. Static memories are composed of cells with the properties of flip-flops which will retain data in the absence of Control signals. Dynamic memories must be continually "refreshed" by exercising the Control signals. The only dynamic memory used in the Control is the 4K memory chip used on the memory board.

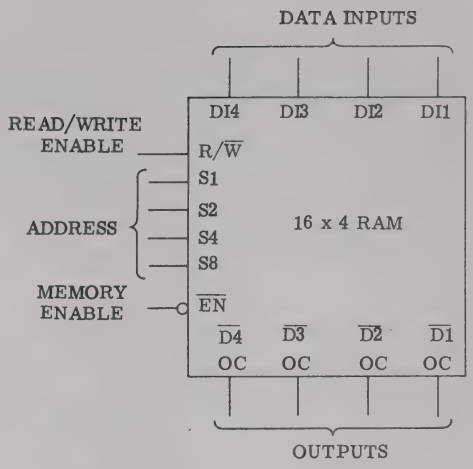
4x4 Memory File

This 16-bit file is organized as four 4-bit registers. Separate address and enable lines are provided for reading and for writing. The output is 3-state which permits connecting to a bus.



16x4 RAM

This 64-bit array is organized as sixteen 4-bit words. Each 4-bit word is addressed in straight binary with the four address lines. The combinations of the read/write enable and the memory enable required for different operations are given by the function table.



FUNCTION TABLE

MEM EN	READ/WRITE	OPERATION	CONDITION OF OUTPUTS
0	0	Write	Complement of Data Inputs
0	1	Read	Complement of selected word
1	0	Inhibit Storage	Complement of Data Inputs
1	1	Do nothing	High

1K RAMS

Two 1K static RAMS are used. One is a 1024 X 1. It requires 10 binary address bits, a read/write select, a chip select and a single data input and data output.

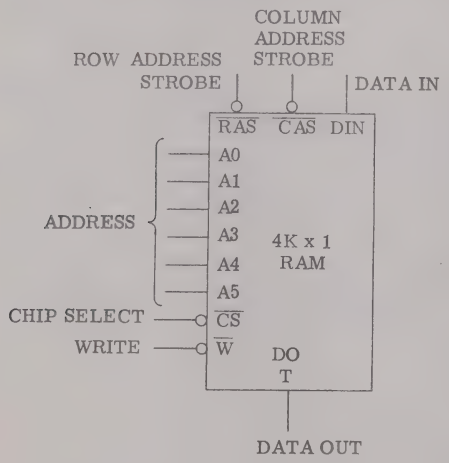
The second 1K RAM is organized as 256 words of 4 bits each. The 256 words require 8 address bits, a read/write select, and 4 data input and output lines. Additional flexibility is provided by having 2 chips select inputs and an output enable.

4K RAM

The 4096 X 1 dynamic MOS RAM used in the main memory is commonly referred to as a 4K RAM. For 4096 locations, 12 binary address bits are required. These 12 bits are supplied in 2 words of 6 bits each on the 6 address lines and latched into the chip by the Row Address Strobe ($\overline{RAS}$) and the Column Address Strobe ($\overline{CAS}$).

The Chip Select ($\overline{CS}$) selects the chip. The Write ($\overline{W}$) input is at logic 0 to write and logic 1 to read.

Circuitry on the chip accomplishes a refresh if a read cycle is performed at each of the 64 row addresses at least every 2 milliseconds.

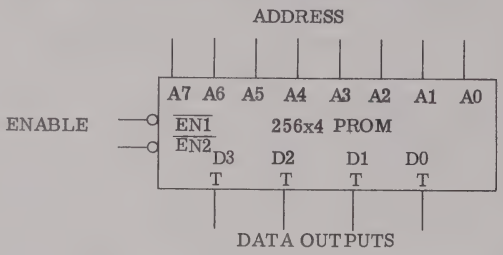


PROM's

PROM's operate similarly to RAM's in the read operation. They are programmed at the factory by electrically changing some physical property, such as blowing a fuse link at every location where a logic 1 is wanted. Some PROM's are programmed by blowing a fuse link to obtain a logic 0.

PROM's are used to permanently store programs or tables but RAM's must be used for data which can change.

A 256 X 4 PROM has 8 address lines for the 256 words and 4 outputs for the 4 bits of the word. The enable inputs are used to select the chip. Other PROM's used in the control are the 32 X 8 and the 256 X 8.

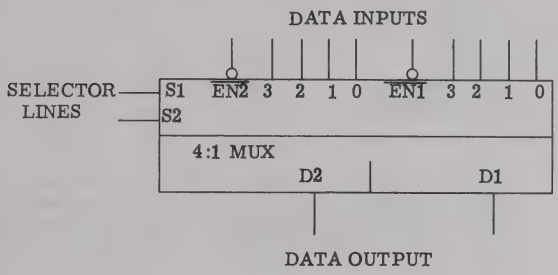


DATA SELECTORS/MULTIPLEXERS

An arrangement of gates which can select data from more than one source is called a Data Selector or Multiplexer. The types used in the Control include

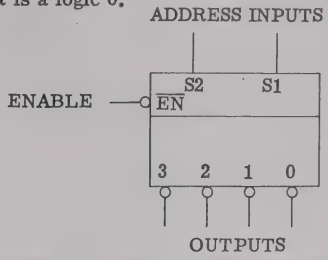
8-line to 1-line
Dual 4-line to 1-line
Quad 2-line to 1-line

The operation can be explained using the dual 4-to-1 shown below. The binary number represented by the logic levels at the selector lines, S1 and S2, determines which input will appear at the output. The two 4-to-1 multiplexers use common selector lines. The output appears only if the enable line ($\overline{EN}$) is logic 0.



DECODERS/DEMULTIPLEXERS

Decoders allow a particular output to be selected as determined by the input at the address lines. One element of a dual 2:4 decoder package is shown. The table shows the input-output relations. The selected output is a logic 0.



INPUTS			OUTPUTS			
ENABLE	SELECT					
$\overline{EN}$	S2	S1	0	1	2	3
0	0	0	0	1	1	1
0	0	1	1	0	1	1
0	1	0	1	1	0	1
0	1	1	1	1	1	0
1	0	0	1	1	1	1
1	0	1	1	1	1	1
1	1	0	1	1	1	1
1	1	1	1	1	1	1

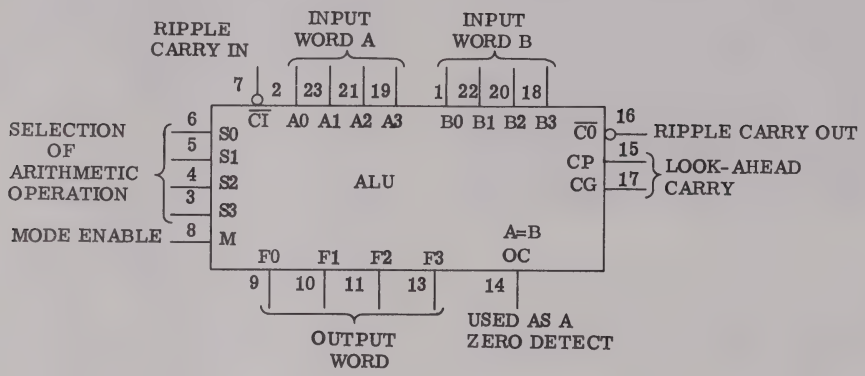
If the enable line is used as a data line, the above element serves as a demultiplexer.

Other decoders will operate somewhat similar to the one just described.

Another element, which in a broad sense may be considered as a decoder, is the Parity Generator/Checker. It has 9 inputs and 2 outputs, EVEN and ODD. If zero or an even number of inputs are at logic 1, the EVEN output is high. If an odd number of inputs are at logic 1, the ODD output is high.

ARITHMETIC LOGIC UNIT (ALU)

The ALU performs 16 arithmetic operations or two 4-bit words or produces 16 logic functions. Mode enable (M) is held at 0 for arithmetic operations and 1 for logic functions.



Operations are selected by the 4 select lines (S0, S1, S2, S3). Logic functions include such results as AND, OR, NAND, Exclusive OR, etc. Arithmetic operations include addition, subtraction, decrement and straight transfer. When performing arithmetic operations internal carries must be enabled by applying a low level voltage to the mode control input (M).

For full carry look-ahead operation, the 2 cascade output pins P and G are used. Where high speed is unimportant a ripple carry input (C_I) and a supply carry output (C_O) are used.

Subtraction (A minus B) is accomplished by 1's complement addition where the 1's complement of the subtrahend is generated internally. The resultant output is A-B-1 which requires an end-around or forced carry to provide A-B.

The A = B output is internally decoded from the function outputs (F0, F1, F2, F3) so that when two words of equal magnitude are applied at the A and B inputs a logic 1 output (positive logic) will indicate that A = B. This output is used to detect a result equal to zero.

The table below shows the results at the output, F, both for logic functions (M = 1) and arithmetic operations (M = 0). This table is only for the case where inputs and outputs are described in terms of barred signals (active state is at logic 0).

SELECTION				RESULT AT OUTPUT F (ACTIVE STATE IS LOGIC 0 FOR INPUTS AND OUTPUTS)		
				M=1 LOGIC FUNCTIONS	M=0 ARITHMETIC OPERATIONS	
S3	S2	S1	S0		CI=D (NO CARRY)	CI=1 (WITH CARRY)
0	0	0	0	$\overline{A}$	A MINUS 1	A
0	0	0	1	$\overline{AB}$	AB MINUS 1	AB
0	0	1	0	$\overline{A}+B$	$A\overline{B}$ MINUS 1	$A\overline{B}$
0	0	1	1	1	MINUS 1(2'S COMP)	ZERO
0	1	0	0	$\overline{A+B}$	A PLUS $(A+\overline{B})$	A PLUS $(A+\overline{B})$ PLUS 1
0	1	0	1	$\overline{B}$	AB PLUS $(A+\overline{B})$	AB PLUS $(A+\overline{B})$ PLUS 1
0	1	1	0	$\overline{A \oplus B}$	A MINUS B MINUS 1	A MINUS B
0	1	1	1	$A+\overline{B}$	$A+\overline{B}$	$(A+\overline{B})$ PLUS 1
1	0	0	0	$\overline{AB}$	A PLUS (A+B)	A PLUS (A+B) PLUS 1
1	0	0	1	$A \oplus B$	A PLUS B	A PLUS B PLUS 1
1	0	1	0	B	$A\overline{B}$ PLUS (A+B)	$A\overline{B}$ PLUS (A+B) PLUS 1
1	0	1	1	A+B	A+B	(A+B) PLUS 1
1	1	0	0	0	A PLUS A*	A PLUS A PLUS 1
1	1	0	1	$A\overline{B}$	AB PLUS A	AB PLUS A PLUS 1
1	1	1	0	AB	$A\overline{B}$ PLUS A	$A\overline{B}$ PLUS A PLUS 1
1	1	1	1	A	A	A PLUS 1

*Each bit is shifted to the next more significant position.

DIGITAL-TO-ANALOG (D/A) CONVERTER

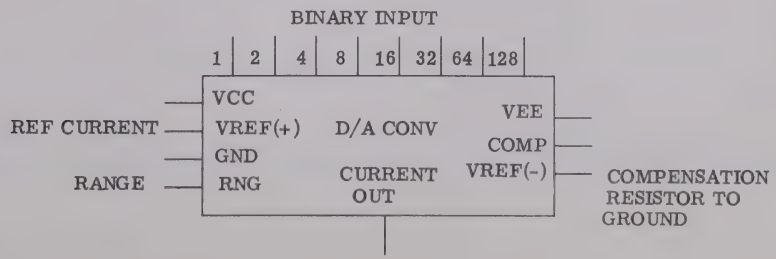
The D/A Converter has an 8-bit binary input and a DC current output. It consists of a reference current amplifier and 8 electronic switches. Each switch turns on an output current component proportional to the binary value of its input.

The full range current is specified by the current into pin VREF (+). This is 256/255 of the value which will be obtained at the output for all 1's at the input, that is, for a digital input of 255. The resistor at pin VREF (-) is selected to be equal to the one at VREF (+) for temperature compensation.

A D/A converter can be used to convert analog to digital by comparing the analog voltage to be converted to a D/A output and using any resulting error to cause a counter to step to a value where the error is zero. The value in the counter is the desired digital value.

SPECIAL PACKAGES

There are several special logic chips which are described with the particular circuit in which they are used. These include microcomputer chips RALU and CROM used in the CPU2 board and UAR/T used on the CPSI1 board.



LOCATING PACKAGE PINS ON A PRINTED-CIRCUIT BOARD

How to locate pins on a printed-circuit board can best be explained by example. Suppose that you wish to locate a pin which is indicated on a board diagram as D3 (package) 11 (pin). You must first locate the package on which the pin is located.

Locating the Package (See facing page)

Holding the board in the same position as that in which it is plugged into the connectors, and looking at its package side, you will see consecutive numbers (1 through a maximum of 15) across the top of the board from right to left; these numbers indicate the vertical rows of packages (or resistors, etc.). On the right and left hand side of the board and several other places, you will see, from top to bottom, letters A through a maximum of P. These letters indicate the horizontal rows of packages. Since you know that D3 is in vertical row D and horizontal row 3, you are able to locate the exact package.

Locating the Pin

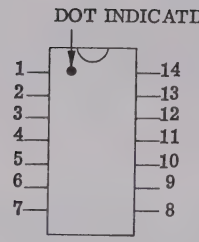
To locate the exact position of the pin on the package, first find the dot on the package. Looking at its package side, you will see that there is a dot on the upper left side of each package. Each dot indicates Pin 1. The pins on a package are numbered in a counterclockwise direction as shown on the sketches.

BACKPLANE PINS

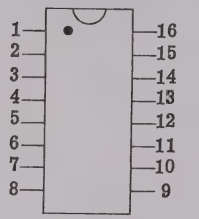
The 86-pin backplane connector is numbered from top to bottom with odd numbers on the right when looking at the backplane side. On the board, the odd pins are the ones farthest from the edge.

BOARD HANDLE END PLUGS

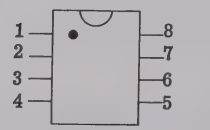
The handle end plugs are designated UPL and LPL for upper and lower plugs. If there is a middle plug also, it is MPL.



14-PIN PACKAGE

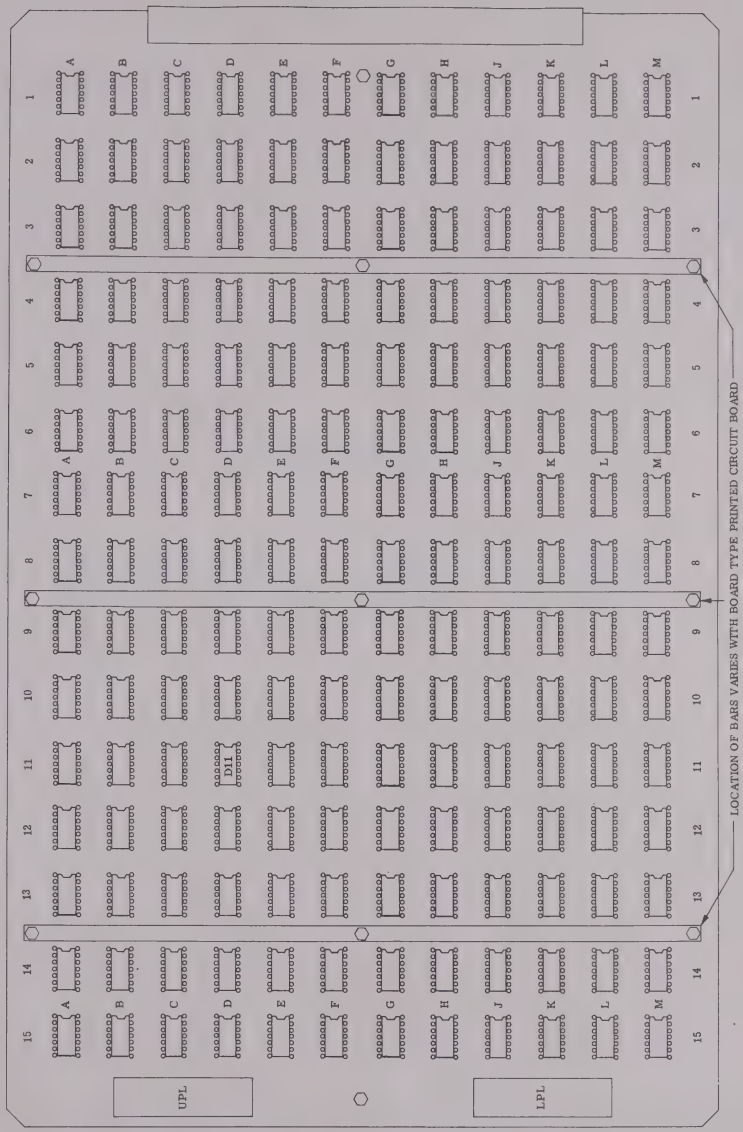


16-PIN PACKAGE



8-PIN PACKAGE

TOP VIEW

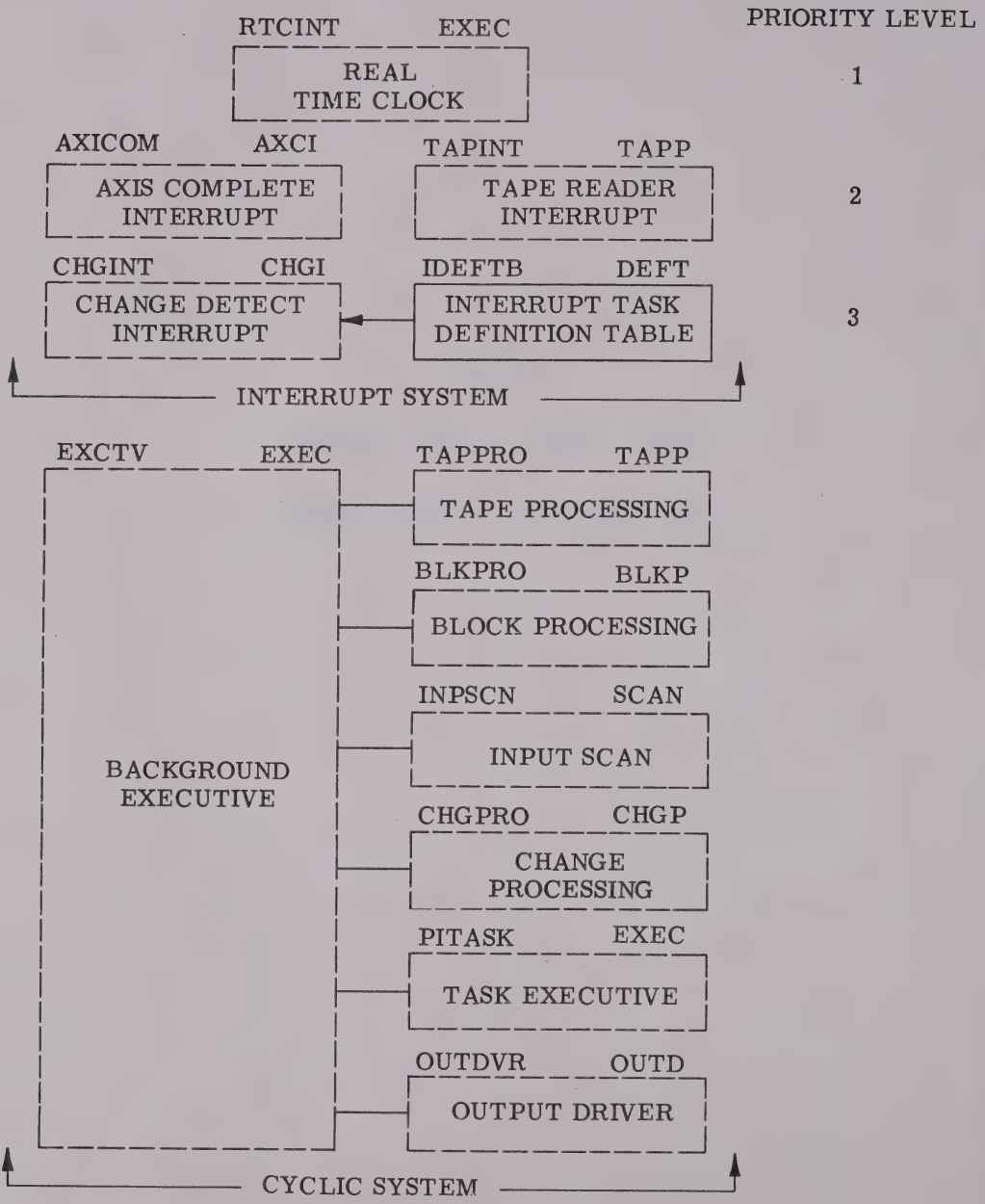

UPL
LPL
D11
LOCATION OF BARS VARIES WITH BOARD TYPE PRINTED CIRCUIT BOARD
PRINTED CIRCUIT BOARD - PACKAGE SIDE

CHAPTER VII

HIGH LEVEL FLOW CHARTS

1050T
HIGH-LEVEL FLOW CHARTS
OF EXECUTIVE SOFTWARE

1050T SOFTWARE HIERARCHY



SOFTWARE HIERARCHY

Program blocks are identified by the program symbol at upper left, and the software module title at the upper right of each block.

The interrupt system has priority over the cyclic system. Within the interrupt system, priorities are indicated by the position on the page. The highest priority level of 1 is assigned to the real time clock, RTCINT, which can interrupt any other routine. It runs every 4 milliseconds, and has an execution time of about 40 microseconds.

Axis complete interrupt, AXICOM, and tape reader interrupt, TAPINT, share priority level 2. Only the real time clock can interrupt them. They can interrupt lower-level routines. Axis complete interrupt responds to an actual or simulated axis-complete interrupt. Tape reader interrupt responds to a tape reader interrupt which occurs when a tape character is available. Axis complete interrupt and tape reader interrupt are described under Part Program Data Flow.

Change detect interrupt, CHGINT, responds to selected input filter (IF) board inputs which have been given interrupt capability to permit prompt response. Change detect interrupt reads in and examines the IF inputs which could have caused the interrupt and causes any appropriate high-priority task (program) to be executed, identifying such tasks by means of the interrupt task definition table IDEFB. The interrupt task definition table is shown with solid lines to indicate that it is a data storage area.

The cyclic system runs as a background activity, subject to interrupts, under the control of the background executive (EXCTV). Background executive causes sequential execution of the 6 routines shown on a continuing cyclic basis. Two of the 6 routines, tape processing and block processing, are related to part program data flow. The remaining 4 are described under digital data flow.

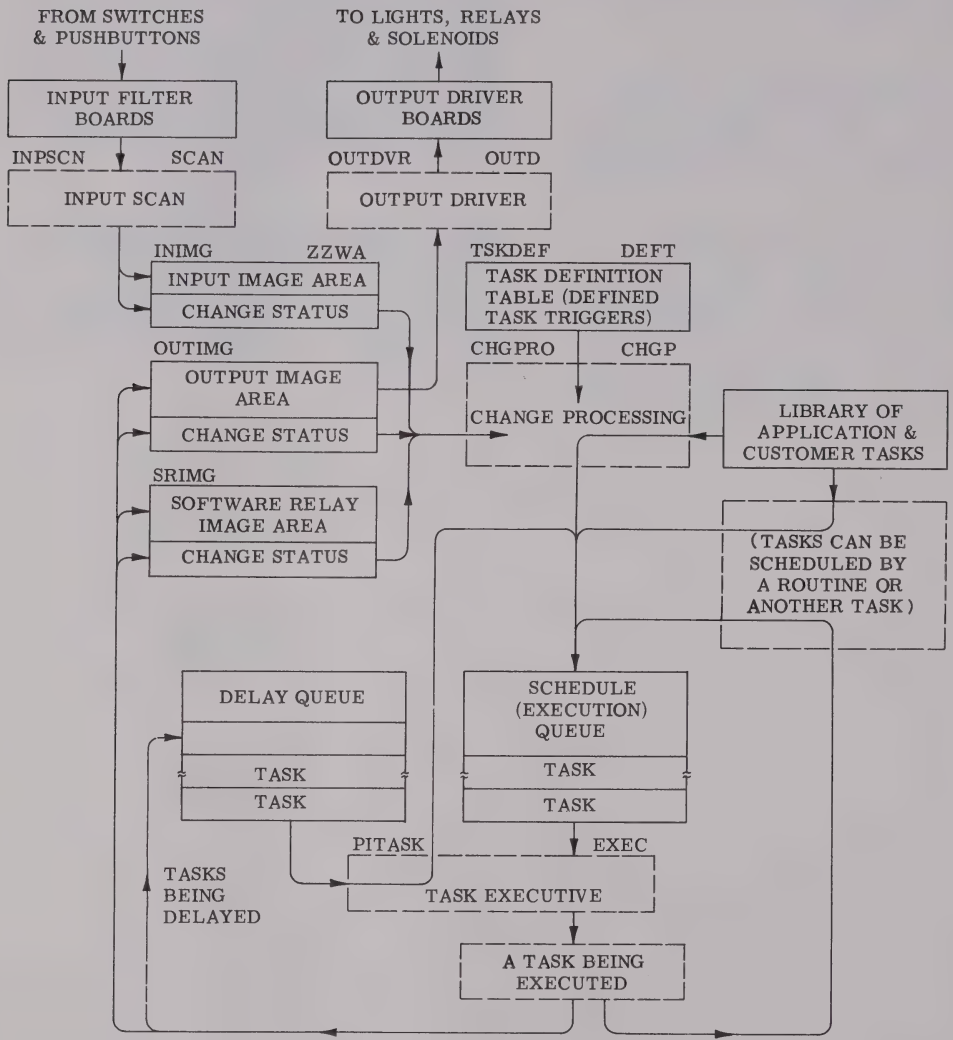
NOMENCLATURE

ADDRESS LABEL — MODULE NAME

SOLID BOX - DATA STORAGE AREA

DOTTED BOX - PROCESSING OR TRANSFER

DIGITAL DATA FLOW



DIGITAL DATA FLOW

Digital data refers to non-axis information which enters as signals from pushbuttons and switches connected to input filter boards, and leaves as signals sent out from output driver boards to lights, relays, and solenoids. It includes internal flags which indicate the current status of parts of the system.

Data processing between inputs and outputs is accomplished by a group of programs called tasks, which are selectively executed as needed to perform the required functions. The digital data flow chart illustrates the technique of selecting and executing tasks. It does not describe the actual content of the tasks themselves. Tasks directly associated with non-axis machine tool activities such as spindle or coolant control are identified as customer tasks. Tasks related to functions internal to the Control are called application tasks.

Input scan (INPSCN), running periodically as a routine of the cyclic system, reads the state of each input filter (IF) board and stores a software image of the board in the input image area (INING). Input scan stores the state of the 32 elements of an input filter board as individual bits in two 16-bit image words. It also compares each new image word with the old image being replaced and records any differences found by setting the corresponding bits in a change status word. Image and change status words are interlaced in the image area, each image word having its associated status word.

A second image area, output image area, contains similar image and status words for the 32-element output driver boards. A third area, software relay image area, contains similar words for so-called software relays, which are bits set and cleared as part of internal system logic.

Change processing (CHGPRO) is a routine of the cyclic system. It checks each status word of all 3 image areas against bit-defining entries in the task definition table (TSKDEF) to identify tasks which should be executed. When a match is found, the appropriate task, identified by serial number, is put on the schedule queue for later execution (unless it is already queued).

The process of schedule executing a task is represented as the physical transfer of the task from a library of tasks to a position in a schedule queue which operates as a first-in, first-out stack. In reality, a threaded list technique is employed, by which a task is put onto the schedule execution or removed from it by the changing of certain entries in a 4-word control block associated with each task. The task control blocks are not shown on the chart.

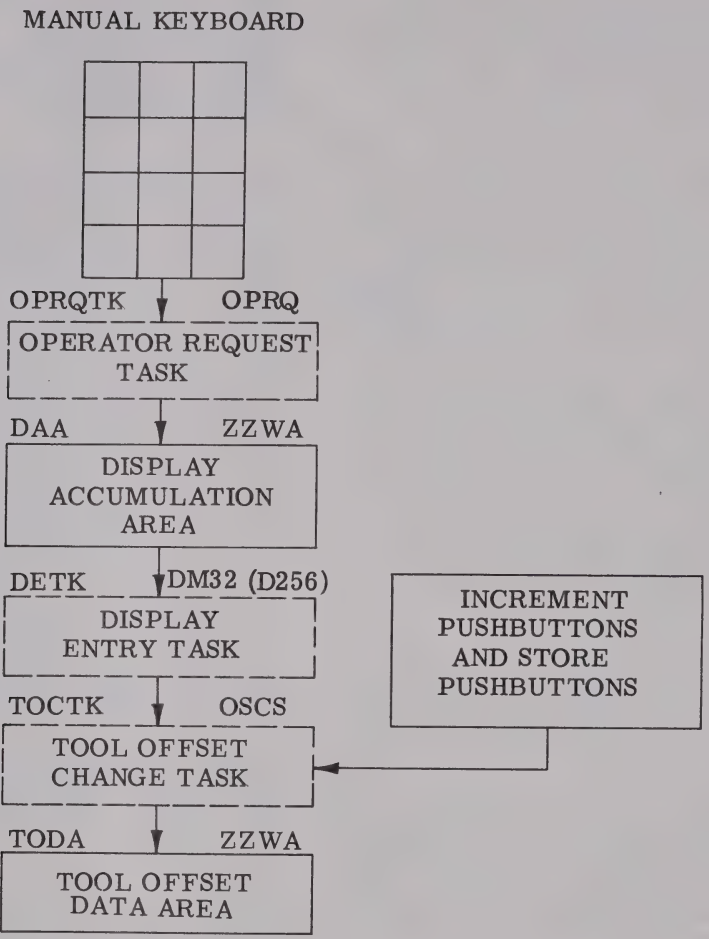
Tasks can enter the schedule queue by 2 means other than change processing. The right-hand path shown represents the ability of a routine or a task being executed to schedule other tasks, using instructions which put the appropriate entries into the tasks control blocks. The left-hand path into the schedule queue originates from another queue called the delay queue. This queue permits a task to hold up its own execution for a programmed delay time. Conceptually, a programmed delay transfers the task onto the delay queue, but not necessarily to the end of the queue. The task is inserted among any other delayed tasks already in the queue, after considering the delay times not yet expired for each. The order of tasks in the delay queue then corresponds to the eventual order of resumed execution. The actual means of delay queuing is by entries in the task control blocks, which include a time value, and an entry point address at which delayed execution is to be resumed.

The task executive routine (PITASK), run in the cyclic system, transfers from the delay queue to the schedule queue any delayed task whose delay time has expired, and, when the schedule queue is not empty, removes one task (the longest-present) from the queue and executes it. A task being executed may modify the output image areas and software relay image area.

Although the library of tasks and the schedule queue are shown on the digital data flow chart, programs in other areas of the software can set software relays and thereby cause necessary tasks to be scheduled and executed.

The output driver routine (OUTDVR) part of the cyclic system writes data out to all the output driver boards each time it is executed. The data written is obtained from the output image area (OUTIMG).

TOOL OFFSET STORAGE



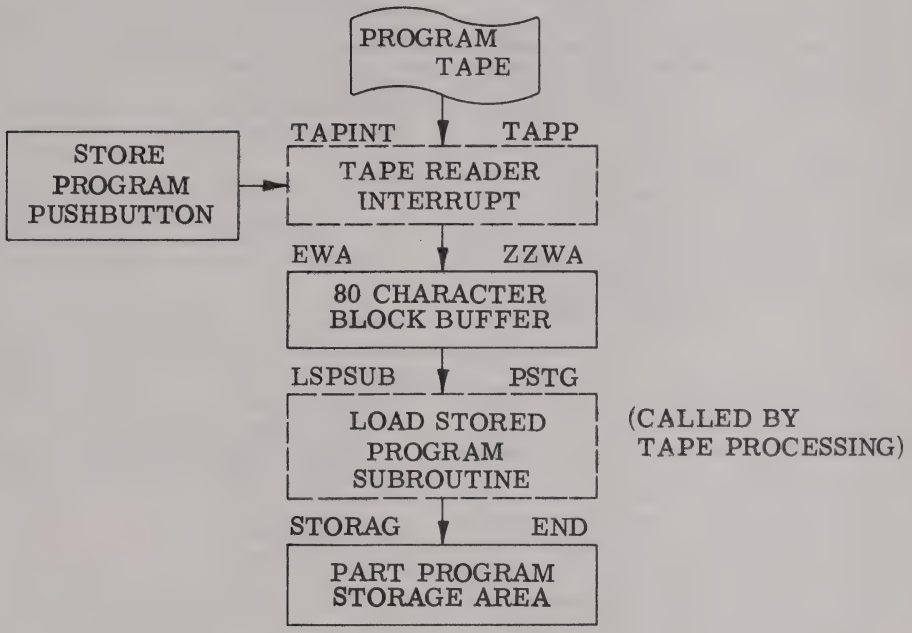
Tool offset storage allows the operator to set up and change the tool offsets as stored in memory. The Display selector switch is in the OFFSET PERMIT STORE position. The Letter Address switch is used to indicate the axis data to be changed.

The data is entered in the MDI keyboard and stored by the operator request task in the display accumulation area. The display entry task displays the old data and the new data being entered. When the operator depresses the Store or Store and Move pushbutton, the tool offset change task converts the data to binary and stores the data in the tool offset data area. If the offset is the active offset, the task causes the axis to move the correct distance.

Also, the operator can change the offset by increments of 1 and 10 by using the Increment switch and pushbuttons. These changes are handled directly by the tool offset change task.

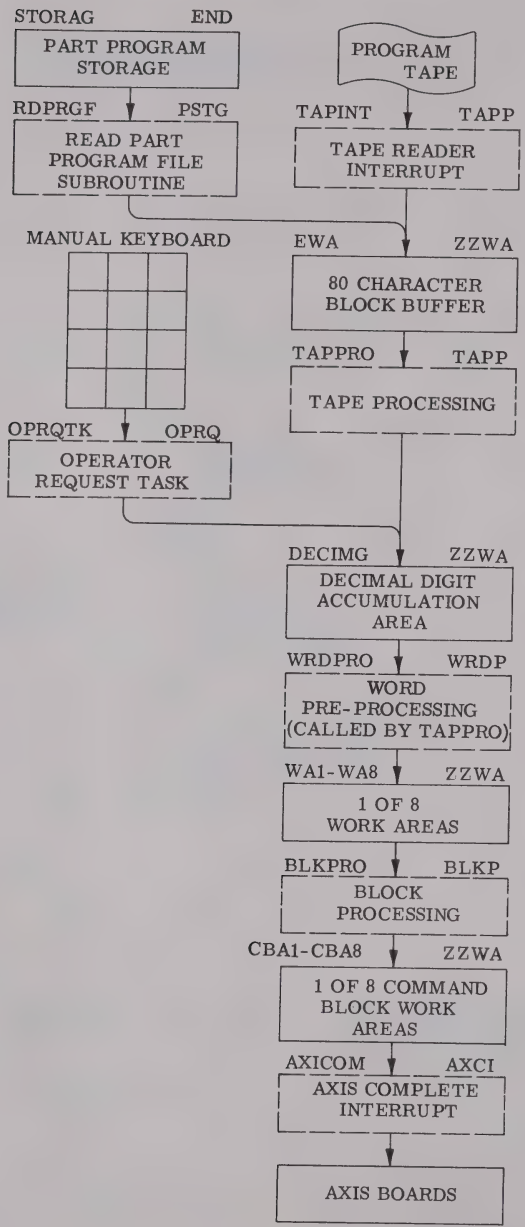
PART PROGRAM STORAGE

PROGRAM SETUP DATA FLOW



The part program storage flow chart shows a part program from tape to memory. The stored program is essentially a direct image of the tape program. RS-244 tapes, however, are translated to the RS-358 code before storing.

PART PROGRAM DATA FLOW



PART PROGRAM DATA FLOW

The part program data flow chart illustrates the flow of part program data through the software to the machine tool. The 2 primary sources of part programs are the tape reader and part programs previously stored in memory. A third source is the manual keyboard used in the MDI mode.

During part program input from tape, when a tape reader interrupt indicates that a tape character is available, the tape interrupt routine (TAPINT) transfers the character from the tape reader buffer to an 80-character buffer (EWA). This continues with null, delete, space and tab characters being discarded, until an end-of-search or stop code is read. At that time a flag is set to indicate that a block of data is available for processing.

If the program source is a part program stored in memory, read part program file subroutine, RDPRGF will fill the 80-character buffer from storage in the same manner as the tape interrupt routine.

Tape processing (TAPPRO) runs as part of the cyclic system, moves the data from character buffer to the decimal digit accumulator, providing any needed leading or trailing zeros.

With manual data input, the operator request task (OPRQTK) moves digits from the manual keyboard into the decimal digit accumulation area (DECIMG).

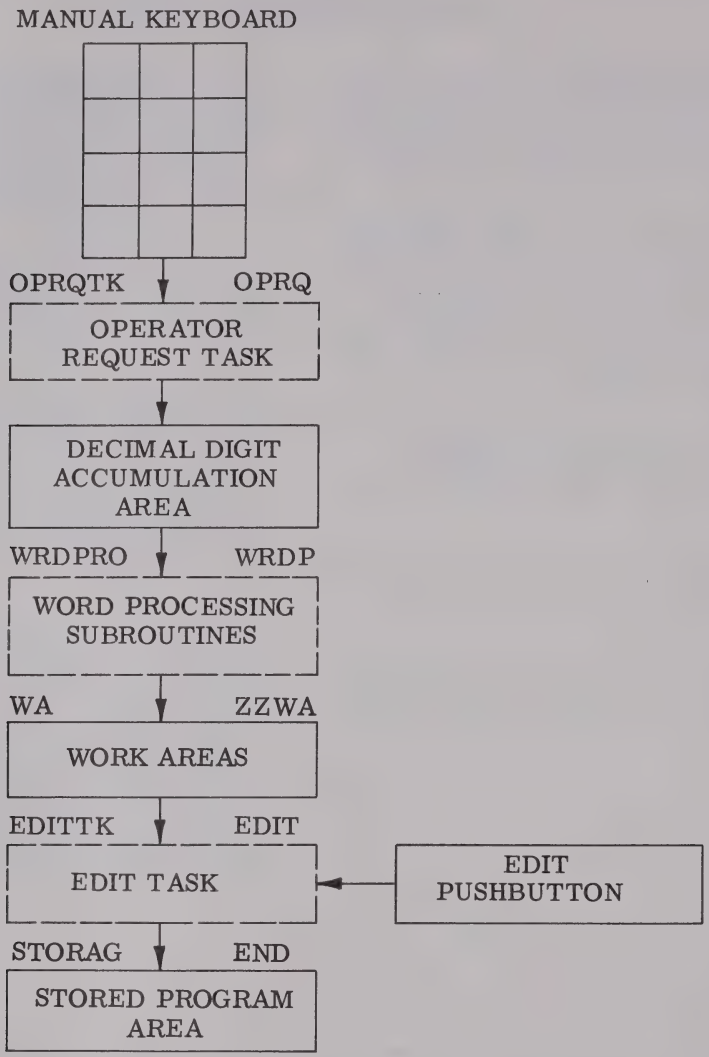
When a complete program "word" (such as n-word or x-word) has been accumulated in the decimal digit accumulation area (DECIMG), word processing, (WRDPRO), a collection of subroutines processes and stores the information into 1 of 8 work areas. Eight work areas of identical format are provided to permit processing of program blocks in advance of the needs of the machine.

The areas are used in a cyclic sequence. Each work area contains space for every expected program word (letter). Numerical data is stored as ASCII characters for display purposes, and dimension words are also converted and stored as 32-bit binary quantities.

Block processing, (BLKPRO) runs as part of the cyclic system. It uses motion data placed in one of the work areas by tape processing, and computes the distance to go into a command block work area. There are 8 command block work areas corresponding to the 8 work areas which supply inputs for block processing. In the command block work area, the data is stored in a binary form and sequence suitable for direct output to the axis boards.

The axis complete interrupt routine (AXICOM), when caused to run by an actual or simulated axis complete interrupt, performs the transfer of the buffer block to active. To produce axis motion, axis data from a command block work area is sent out to axis boards. However, such axis motions may have to be preceded by other activities programmed in the block, such as changing spindle speed, turning coolant on, etc. It checks for the need of such premotion activity by examining data stored in the active work area, and initiates it by scheduling appropriate tasks. The axis complete interrupt routine uses software relays and flags to insure that by simulated interrupts it is rerun as needed to accomplish all required activity.

PART PROGRAM EDIT



Part program edit is available only with the program storage option. The block to be modified or deleted is placed in the buffer work area. This is done by any of the tape search or execution methods. The MDI entry is performed in order to modify the block of data.

When the edit pushbutton is depressed, the edit task will either delete, modify, or insert the block in buffer according to the setting of the Edit selector switch.

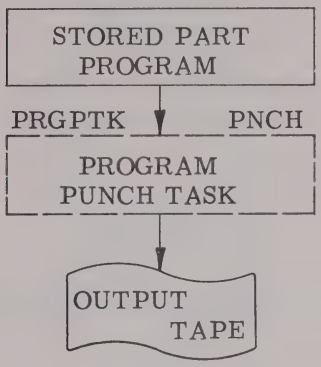
If DELETE is selected, the edit task simply moves all part programs located in higher addressed memory down over the deleted block.

If MODIFY is selected, the data in the buffer work area is formed into a tape image with leading or trailing zeros removed. This image then replaces the image in part program storage.

If ADD is selected, the data in the buffer work area is formed into a tape image as in modify, the data in part program storage is then moved to allow insertion of the new block.

PUNCHING TAPE

PART PROGRAM EDIT

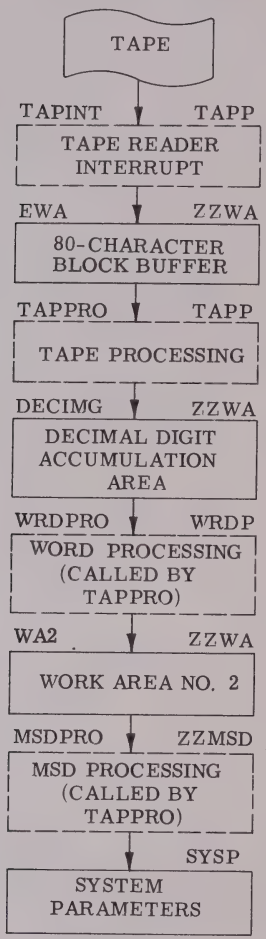


Punching is done by the program punch task, (PRGPTK).

The program may be punched in the RS-244 or RS-358 code as selected by the Punch Code switch. The output is a copy of what is stored in memory.

Punching operations do not cause any change in part programs stored in memory.

MACHINE SETUP DATA FLOW



The machine setup data feature provides a means for altering selected software machine parameters (for example, the reference zeroing direction for each axis).

As the chart shows, machine setup data (MSD) is read in by the tape reader and processed up to the word processing (WRDPRO) subroutine just as normal part programs are. The word processing (WRDPRO) subroutine performs part of its normal job and stores the result in the work area. After a complete block of tape has been stored in the work area, the Machine Setup Data processing (MSDPRO) subroutine is called. This subroutine translates the data into the form needed by the application software and stores the result in the appropriate places in memory. The Machine Setup Data processing program is used during only a short period of time immediately after the software is loaded, so it occupies the same memory space that is used for 5 of the work areas and all of the command block work areas.

INDUSTRIAL CONTROL DEPARTMENT, GENERAL ELECTRIC COMPANY, WAYNESBORO, VIRGINIA
PRINTED IN U.S.A.

CHAPTER VIII
MAINTENANCE

MAINTENANCE

The side panels of the Control enclosure should be opened only when necessary for service or inspection and then only by qualified personnel. There is considerable evidence to support the belief that serious failures are caused by the careless use of screwdrivers, pliers, clip leads, test probes, etc.

WARNING

HAZARDOUS VOLTAGES! SERVICING OF THIS CONTROL SHOULD BE REFERRED TO AN AUTHORIZED SERVICE TECHNICIAN.

The only items requiring operator maintenance besides those which are described in other chapters of this book and below, are the fans, inside and outside surfaces of the Control, and the air filter located in the top of the back door.

AIR FILTER

The air filter, located in the rear door of the enclosure, must be removed and cleaned periodically. The degree of cleanliness of the surrounding air has very direct bearing on the frequency of cleaning required. Unclean air will cause the filter to become clogged so that air passage into the Control becomes restricted. Reduction in ventilating efficiency may cause the Control to overheat. In dusty or dirty locations, therefore, the filter should be checked daily.

Clean the air filter with hot water and a detergent or with any type of solvent, and then wring the filter as dry as possible. Do not oil the filter. Replacement filters (No. 44A235705-044) may be ordered from the Industrial Control Products Department of the General Electric Company, Waynesboro, Virginia.

FANS

Heat is transferred from the components to the internal air of the Control, then to the sides and top of the interior of the case. It is then conducted through the case skin and tubes and, by radiation and forced conduction, it is transferred to the outside air.

Circulating fans are used to cool the components and transfer the hot air to the cooling surfaces. If the Overtemperature thermostat should turn the Control off, check the operation of the fans to see if they are rotating. If they are rotating, check the surfaces in accordance with the paragraphs which follow.

Two fans are located in the plenum (small enclosure) located on top of the control enclosure. It is possible for a fan here to fail and not move enough air to provide adequate cooling. Check these fans to see if they are moving air into the plenum down through the heat tubes, and out the bottom of the control.

Since the fans are lubricated for the duration of their life, maintenance is not required except possibly to clean the blades of any accumulated dirt and grease which would restrict air flow. Do so by wiping them clean rather than by the use of solvents which may allow the dissolved dirt to drip or run into the fan motors.

COOLING SURFACES

If the fans are rotating and the Overtemperature thermostat has tripped off the Control:

CAUTION

REMOVE ALL POWER BEFORE OPENING THE ENCLOSURE.

1. Remove the side panels of the case and clean the inside and surfaces with a dry cloth and a cleaning rod to remove any accumulated dust or dirt.

Figure 1, GEK-45670, General Description and Installation, shows how to remove the side panels of the enclosure.

2. Reach into the air plenum from all sides of the Control, wiping the top of the Control until it is clean.

3. Clean the internal tubes and walls of the hollow-walled side panels. Since these surfaces are the least likely to cause trouble, this step is the final one to be taken. These surfaces may need to be steam cleaned if they have accumulated dirt-laden oil and grease.

TAPE READER

Adherence to the schedule set forth below will aid you significantly in realizing optimum reader performance.

TAPE READER
PREVENTIVE MAINTENANCE SCHEDULE

ITEM	ACTION	TIME INTERVAL
Lamp/Lens	Dust, using a soft cloth, cotton swab, or brush.	Daily
	Clean, using sparing amounts of pure isopropyl alcohol.	125 hours
Tape Guides, Reader Photocell Assembly and Guide Rollers (Reeler only)	Dust, using a soft cloth, cotton swab, or brush from the maintenance kit.	Daily
	Clean, using sparing amounts of pure isopropyl alcohol.	125 hours
Photocells in Reel Arm Feedback Assemblies (Reeler only)	Remove the cover over the photocell assemblies. Clean the faces of the photocells with a cotton swab dipped in pure isopropyl alcohol.	2000 hours or as required
Drive Motor and Reel Motors	NO LUBRICATION is required for the life of the components.	
Reel Motor Brushes	Check the length of the brushes and replace them when their length is 5/16" or less. When the brushes are removed for checking, each brush must be replaced in the same holder from which it was removed.	Check the brush length every 2000 hours and replace it as necessary.
Fixed and Movable Guide Roller Bearings (Reeler only)	Sleeve Type Lubricate with ONE drop of an oxidation resistant mineral oil such as Gulf A&E or Tereso T-43 or T-52. Apply at the junction of the shaft and bearing. CAUTION: Do not overlubricate. Roller Type NO LUBRICATION is required for the life of the components.	Every 500 hours or as required
Tension Arm Shaft Bearings (Reeler only)	NO LUBRICATION is required for the life of the components.	

BATTERIES

The sealed batteries require no maintenance other than a periodic examination of terminal connections.

Battery replacement is considered to be a normal maintenance item with battery life being dependent on the number of discharge cycles to which the batteries are subjected. The normal life of the battery is 300 (minimum) complete discharge cycles.

As an example:
When a battery is completely discharged every day during a year, its life may be as short as one year.

If however, the battery is only partially discharged every day and completely discharged on weekends, battery life would be approximately 2 to 3 years. The failure of a Control to maintain memory for the time period that is specified on page 10 of GEK-36037 may indicate that the batteries should be replaced.

OPERATOR'S CONTROL PANEL

Periodic cleaning of the control panel will enhance the Control's appearance and maintain the readability of the displays and indicators. The control panel may be cleaned with any non-solvent type of industrial cleaner, isopropyl alcohol, or Windex. Apply cleaner sparingly and wipe dry using a soft cloth.

MAINTENANCE RECORDS

Most users develop a procedure for keeping records showing maintenance routines including dates of lubrication, details of "down" time, results of various checks, and information concerning service calls. Such records are strongly recommended. They will often help the serviceman locate the trouble and will prevent small defects from leading to serious breakdowns.

The format for maintenance records may vary greatly, inasmuch as these records are often effectively combined with the other machine-maintenance records. It is left to the user to develop the maintenance records which will best fit each application.

MAINTENANCE DESCRIBED IN OTHER CHAPTERS

Maintenance information (including adjustments) may also be found in the Servo and Tape Reader chapters of this book.

CUSTOMER'S TERMINAL BOARDS

Normally these terminal boards do not require cleaning. However, if it should become necessary to clean them, they should be cleaned only with the following two cleaners: Freon*, Type TE or TF, and isopropyl alcohol.

CAUTION

Other types of solvents, particularly those containing chlorine, such as carbon tetrachloride can result in damage to the Lexan** body of the terminal boards.

*Trademark, Phillips Mfg. Co.
**Registered Trademark, General Electric Co.

INDUSTRIAL CONTROL DEPARTMENT, GENERAL ELECTRIC COMPANY, WAYNESBORO, VIRGINIA

INSTALLATION & SERVICE
ENGINEERING DIVISION

Electrical and Electronic Service Department

GEK-45564G

Machine Tool Service Locations

EUROPEAN MACHINE TOOL SERVICE

ENGLAND
Mark Century Company . . . . . (0044-21) 454-2141
Hagley House, Hagley Road
Edgbaston-Birmingham
B 16.8 QU, England

FRANCE
General Electric Co. . . . . (0033-1) 921-87-60
53 Rue De Montessuy or
91 260 Juvisy S/Orge 921-87-61
France

GERMANY
GETSCO/I&SEID* . . . . . (0611) 76071
Praunheimer Landstrasse 50
6000 Frankfurt/Main 90

GETSCO 02161-23042
Fliethstrasse 67
4050 Moenchen-Gladbach 1

ITALY
GETSCO 0039-2-48 66 43
Via Vittoria Colonna 4 or
20149 Milan, Italy 43 03 59

SPAIN
GETSCO . . . . . (0034-1) 2479546
Apartado 50 990
Madrid 7, Spain

SWEDEN
International General Electric AB . . . . . (0046-8) 7300740
Fack
Tritonvaegen 27V
17120 Solna, Sweden

U.S. MACHINE TOOL SERVICE

ALABAMA
Birmingham — 2 Metroplex Dr., Suite 301 35209 . . 205 879-2030

ARIZONA
Phoenix — 5320 N. 16th St. 85016 800-423-4013

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Los Angeles — 9350 E. Flair Dr., El Monte 91734 . . 213 572-5188
Santa Clara — 2075 De La Cruz Blvd. 95050 . . . . . 408 925-1680

COLORADO
Denver — 201 University Blvd. 80206 . . . . . 303 320-3089

CONNECTICUT
Meriden — 1 Prestige Dr. 06450 . . . . . 203 238-6800

FLORIDA
Tampa — 2106 S. Lois Ave. 33609 . . . . . 813 877-8311

GEORGIA
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ILLINOIS
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Peoria — 3100 N. Knoxville, Room 116 61603 . . . . 309 688-0209

INDIANA
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Indianapolis — 6321 La Pas Trail 46268 . . . . . 317 298-5332

IOWA
Davenport — 1039 State St. (Bettendorf) 52722 . . . 319 355-0231

KANSAS
Overland Park — 10550 Barkley, P.O. Box 2944 66201 913 967-6287
Wichita — 820 E. Indianapolis Ave. 67211 . . . . . 316 265-2891

LOUISIANA
New Orleans (Harahan) — P.O. Box 23700 . . . . . 504 831-5137
800 East Commerce Road, Suite 300 70123

MARYLAND
Baltimore — Contact Philadelphia, Pa. 215 241-5461

MASSACHUSETTS
Wellesley — 1 Washington Street 02181 . . . . . 617 237-2050

MICHIGAN
Detroit — 22255 Greenfield Rd., Southfield 48075 . 313 552-3230
Grand Rapids — 2821 Madison Ave. 49508 . . . . . 616 241-1122

MINNESOTA
Minneapolis — 1500 Lilac Drive So. 55416 . . . . . 612 542-0200

MISSOURI
St. Louis — 1015 Locust Street 63101 . . . . . 314 342-7715

NEBRASKA
Omaha — 8401 W. Dodge Road, Suite 210 68114 . . 402 397-4500

NEW JERSEY
Florham Park — 6 Vreeland Rd. 07932 . . . . . 201 822-3960

NEW YORK
Buffalo — Contact Syracuse 315 456-7166
Rochester — Contact Syracuse 315 456-7166
Schenectady — Contact Syracuse 315 456-7166
Syracuse — 3532 James Street 13206 . . . . . 315 456-7166

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Charlotte — 141 Providence Road 28207 . . . . . 704 371-3300
Wilmington — 929 S. Kerr Ave., Suite L 28403 . . . 919 799-9170

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Cincinnati — 2621 Victory Parkway 45206 . . . . . 513 559-3553
Cleveland — 1000 Lakeside Avenue 44114 . . . . . 216 523-6269
Columbus — 5080 Sinclair Rd. 43229 . . . . . 614 438-2141

OKLAHOMA
Tulsa — 5138 Peoria Avenue 74105 . . . . . 918 743-6446

OREGON
Portland — 2929 NW 29th Avenue 97210 . . . . . 503 221-5060

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Philadelphia — 3 Penn Center Plaza 19102 . . . . . 215 241-5461
Pittsburg — 300 Sixth Ave. Bldg. 15222 . . . . . 412 566-4131
York — Contact Philadelphia 215 241-5461

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CHAPTER IX

HARDWARE TROUBLESHOOTING
DIAGNOSTIC SOFTWARE
COMPUTER ACCESS PANEL

TROUBLESHOOTING 1050T OR 1054T CONTROL

This publication used in conjunction with "Diagnostic Software", GEK-36093, provides the troubleshooter with information necessary to enable him to keep the 1050T or 1054T Control operating efficiently. Areas covered are:

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SECTION 1
MALFUNCTIONS, TEST DIAGNOSTIC PROGRAMS AND TROUBLESHOOTING PROCEDURE

MALFUNCTIONS EXTERNAL TO THE CONTROL

Before starting in-depth troubleshooting, check that the problem is not caused by conditions external to the Control such as:

Machine device
Motion on a limit switch
Limit Switch not working properly

Then check for:

Bad electrical connections
Connections to junction box of machine tool
Control/customer terminal board connections

WARNING

HAZARDOUS VOLTAGES! SERVICING OF THIS CONTROL SHOULD BE REFERRED TO AN AUTHORIZED SERVICE TECHNICIAN.

COMMON POSSIBLE MALFUNCTIONS

Although certain malfunctions are general in nature, they may cause a variety of specific symptoms in the Control which would be quite misleading. Following is a list of items which should be checked before troubleshooting is begun:

1. Power sources
   - A. Fuses
   - B. AC and DC power supply voltages
2. Tape Program (See Chapter IV)
3. All Connections
   - A. Printed-Circuit Boards
   - B. Plug-in Connectors

Excessive vibration and shock (e.g., during transportation) may shake one or more boards partially out of their sockets. The boards may have been incompletely inserted during troubleshooting by substitution of boards. Note that an incompletely inserted board, which may be partially energized, may cause an intermittent malfunction. Make sure that all boards and connectors are firmly in their sockets.

4. Switches
   - A. Limit switches
   - B. Switches on operator's panel
   - C. Customer's interlocks
   - D. Test/Normal/Dry Run

Make sure all switches are in the proper position for the desired mode of operation.

5. Wires and sockets

Wires and sockets may be broken due to mishandling of the Control. Usually a broken wire or connector is fairly obvious after a few minutes inspection (with power switched off).

6. Arc-suppression circuits

A malfunction which starts or coincides with the operation of a solenoid or relay in the Control or machine (including any auxiliary magnetics associated with the system) may be caused by a failure in the Arc-suppression circuits.

7. Power line transients

A malfunction which starts or coincides with the operation of any machinery or apparatus connected to the same AC power line as the Control, may be caused by excessive line transients.

TEST/DIAGNOSTIC PROGRAMS

Operation of the Control's logic may be conveniently tested by exercising the Control with the Diagnostic Test Programs as described in GEK-36093. The Diagnostic Tests should be performed in the following sequence.

1. Central Processor Test
2. Memory Test
3. System Diagnostic Test

Since the Central Processor test requires the least amount of hardware, it is run first. The Memory Test is run second and the System Diagnostic Test is

run last. The System Diagnostic Test requires satisfactory operation of both the Processor Test and Memory Test before it will operate properly. The purpose of the Diagnostic Test Programs is to identify a faulty logic board. Normally the faulty board will be replaced. It is necessary to run all 3 tests in order to verify satisfactory operation of the Control.

Under certain circumstances it may be necessary to repair a faulty board. When attempting to repair a board, the error codes that are defined in GEK-36093 will aid in locating the faulty component.

TROUBLESHOOTING PROCEDURE

For the purpose of troubleshooting, consider that the Control is divided into functional blocks. Each block may represent a complete printed-circuit board which, when tied in with all of the other blocks make up the complete Control (Figure 1, page 4).

The operational block diagram (Figure 1) shows the approximate relationship of the various functional blocks and the primary interconnections between the blocks. Note that a malfunction in one block may affect a number of operations.

When symptoms of a malfunction occur, isolate the problem to a functional block by performing the diagnostic tests as described in GEK-36093 and in the detailed troubleshooting procedure that follows. The troubleshooting sequence begins (Section 3 on page 14) by listing error conditions that may be observed, and follows through with a list of causes in the most probable order.

Section 2 "Operation of Logic Boards" (page 5) should be reviewed unless you are already familiar with it before you begin troubleshooting.

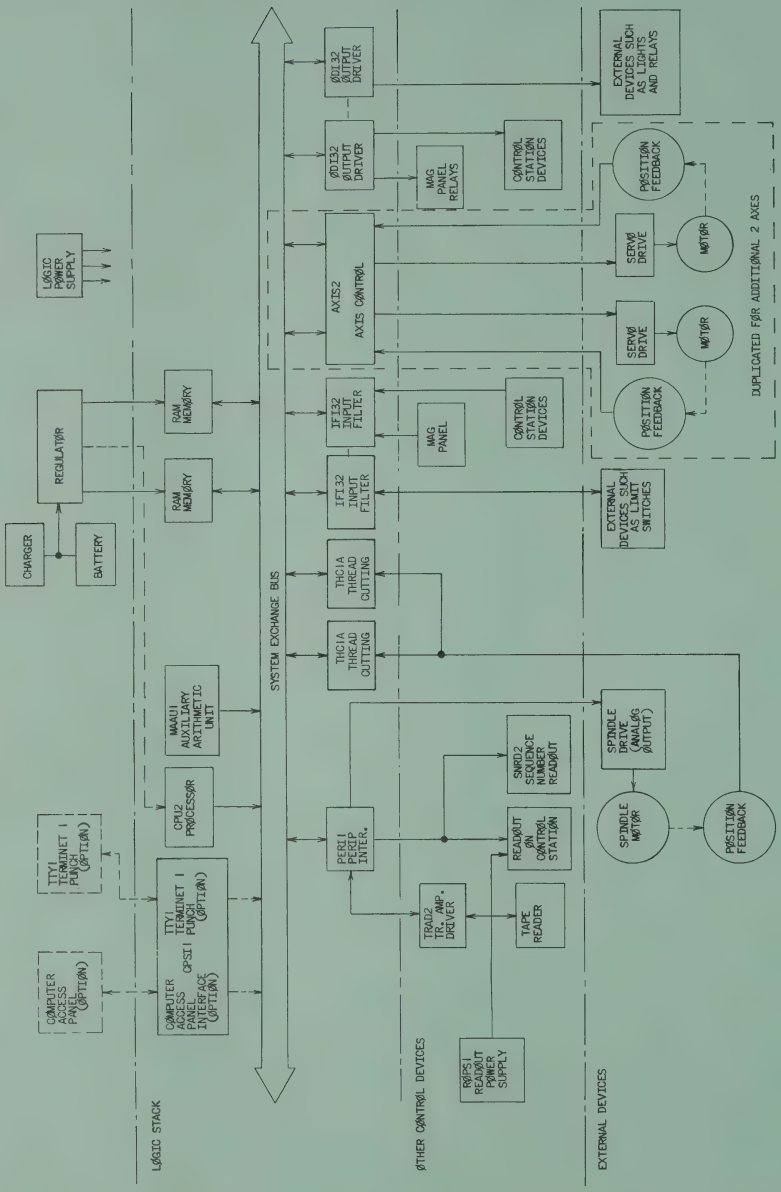


Figure 1.
BLOCK DIAGRAM OF THE 1050T

Ref. 44C285857
Sheet 14

SECTION 2
COMMUNICATION WITH LOGIC BOARDS

All of the logic boards share a common bus system on the logic rack backplane. In general, all of the data exchange between boards is controlled by the Central Processor (CPU). A unique board addressing scheme enables a single board to have access to the command and data buses on the backplane. There are 2 methods of exchanging information between the CPU and other boards. One method is for the CPU to initiate a data exchange at predetermined intervals of time: this is called a Scan mode. The second method is for the board to activate a special interrupt line on the backplane to indicate that it requires an exchange of information with the CPU: this is called an Interrupt mode. Not all boards are capable of operating in the Interrupt mode; hence, they may only be serviced in the Scan mode.

Before the CPU can exchange data with a logic board, the board must be addressed. Addressing is accomplished by the CPU enabling the following backplane lines:

AXIS	(1)	Board Class - Enable only one class of board.
ODRVR	(2)	
IFLTR	(3)	
PERIPHERAL	(0)	
$\overline{BS0}$	($\bar{1}$)	Board Select - Enable any combination to select one of sixteen boards of the selected class.
$\overline{BS1}$	($\bar{2}$)	
$\overline{BS2}$	($\bar{4}$)	
$\overline{BS3}$	($\bar{8}$)	

Address decode gating on each logic board permits that board to decode the lines listed above and to respond when it is addressed. Once a board is addressed, it acknowledges by pulling the $\overline{AK}$ (Pin 28) signal to a logic 0. During the period that the board is addressed it responds to additional instructions. Wire-wrap strapping on the board selects a particular address.

One of 4 instructions may be issued by the CPU. These instructions determine the type of operation which is to take place.

The 4 instructions are:

Write Data (WD) - Data is sent on the system exchange bus from the CPU to a board. Example: Data sent to an ODI32 board to turn the drivers on or off.

Read Data (RD) - Data on the system exchange bus is being sent by a logic board to the CPU. Example: Data from an IFI32 board to the CPU. The data contains the states of all inputs to the IF board.

Output Command (OC) - Command information is sent on the system exchange bus from the CPU to a logic board. Example: A Command instruction to the PERI1 board that causes the tape reader to run.

Sense Status (SS) - Status information is sent from a logic board to the CPU over the system exchange bus. Example: Sense status of the MAAU board to determine if an operation has been completed.

Data that is placed on the system exchange bus may be in bytes (8 bits) or words (16 bits). When bytes of data are to be exchanged, the system exchange bus low ($\overline{SE0}$ through $\overline{SE7}$) is used. The CPU insures that the data being exchanged is taken from, or placed on, the correct system exchange lines (low or high). The system exchange buses are unique in that each is a three-state bus. The states are: logic 0, logic 1, and an off or high impedance state. While monitoring the buses with an oscilloscope the data on the buses is only valid when one of the operation select signals is logic 1. At other times the buses may assume a level anywhere between logic 1 and 0.

Six lines ($\overline{BWC0}$ through $\overline{BWC5}$) referred to as byte-word counter lines, provide a means by which the CPU may address memory locations on a logic board. These lines are activated during the period of time that the address and operation select are active. The logic board then uses the signals in its internal memory addressing circuits. The memory on a board (other than a RAM type) varies in size from 1 to 64 bytes or words. The byte-word counter lines are only used in conjunction with write data and read data instructions.

Figures 2 through 8 are timing diagrams that illustrate the timing relationship of the various signals.

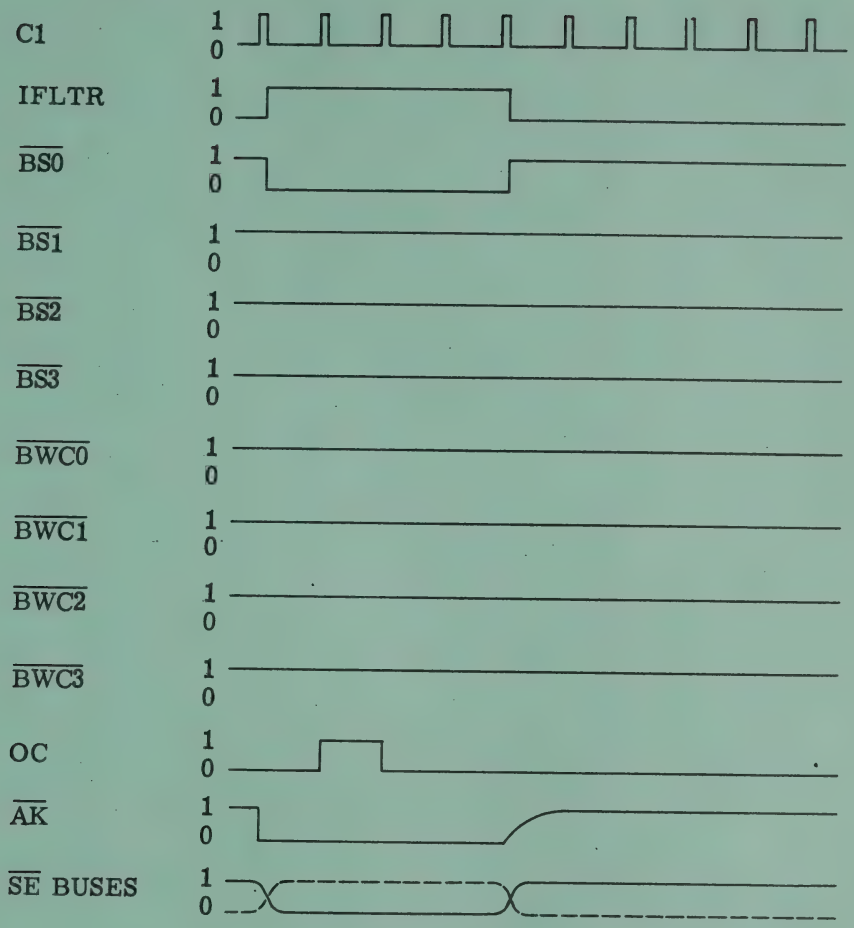


Figure 2.
TIMING FOR AN OUTPUT COMMAND INSTRUCTION TO IFI32*1

NOTE: The system exchange buses will vary with the contents of the instruction

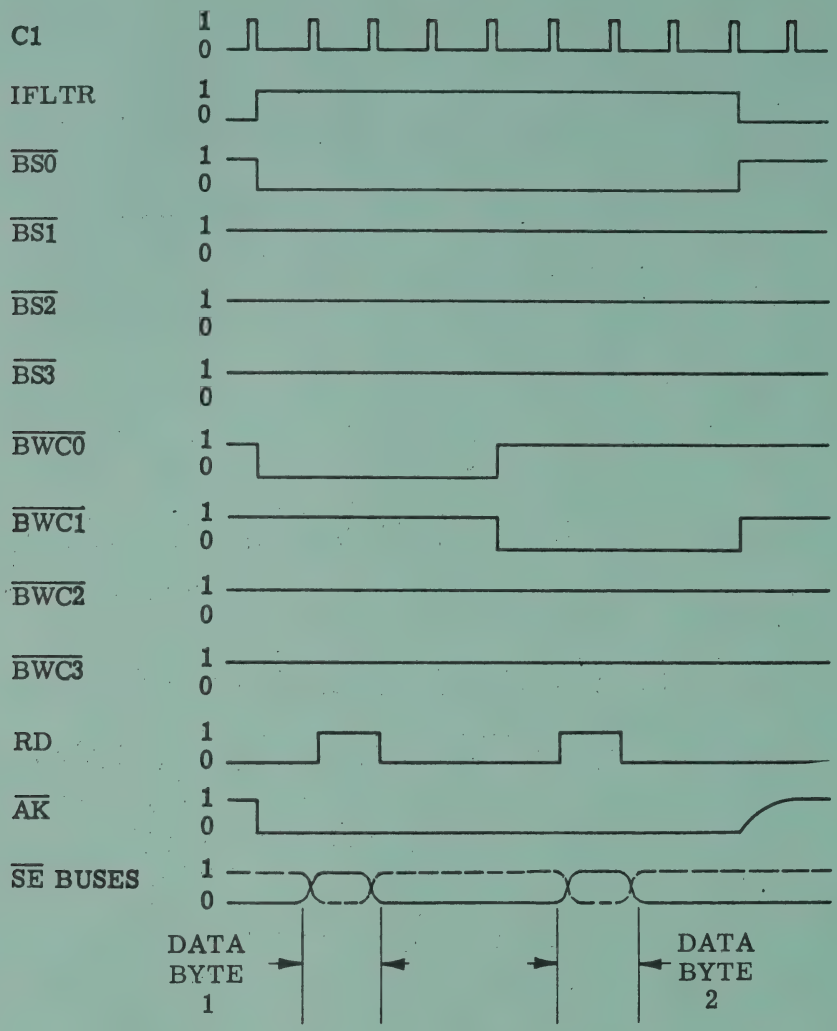


Figure 3.
TIMING FOR READING DATA FROM AN IFI32*1 BOARD

NOTE: The Read data instruction is a read byte double instruction. All of the system exchange buses have not been shown since they will vary with data.

Two bytes of data are being gated onto the system exchange buses, one on byte each time signal RD is at a logic 1 level.

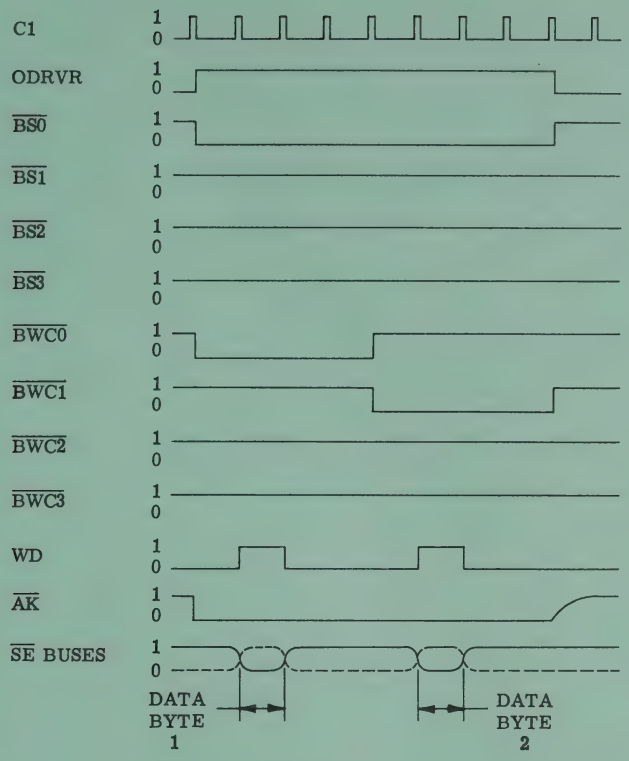


Figure 4.
TIMING FOR A WRITING DATA TO ODI32*1 BOARD

NOTE: The write data instruction is a write byte double instruction. All of the system exchange buses have not been shown since they vary with data.

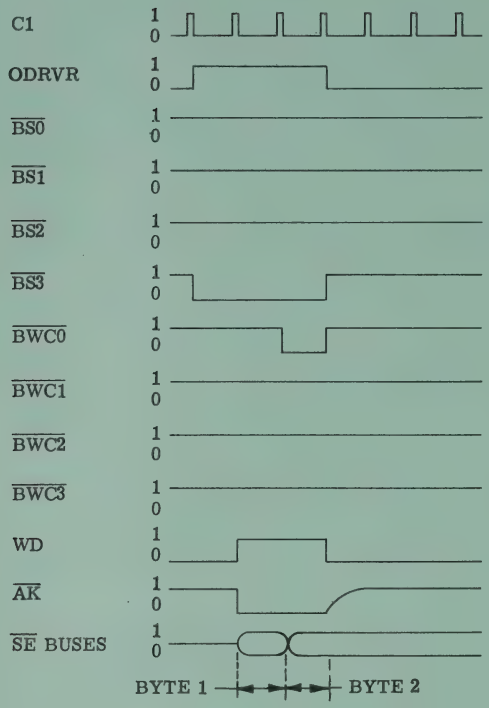


Figure 5.
TIMING FOR WRITING DATA TO AN ODI32A*8 BOARD

NOTE: The write data instruction is a write byte double instruction. All of the system exchange buses have not been shown since they will vary with data.

The timing of the ODI32A, for addresses of 8 through F, will be as shown above. For adress of 1 through 7, the timing will be identical to the timing of an ODI32.

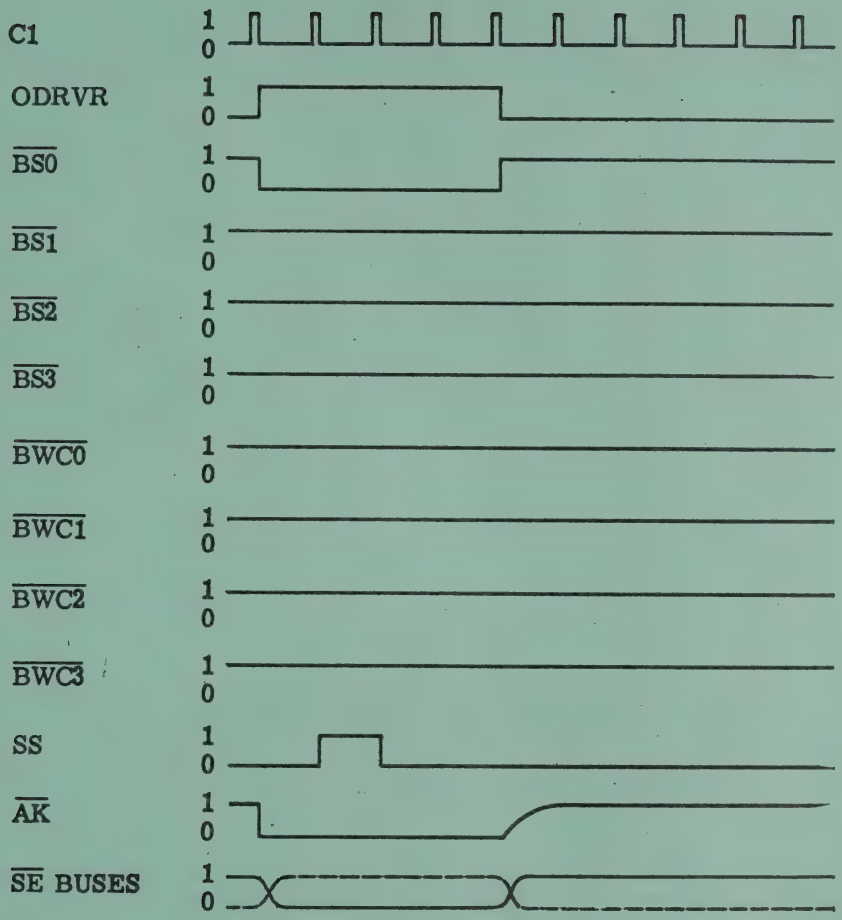


Figure 6.
TIMING FOR A SENSE STATUS INSTRUCTION TO ODI32*1

NOTE: The system exchange buses vary with the status information.

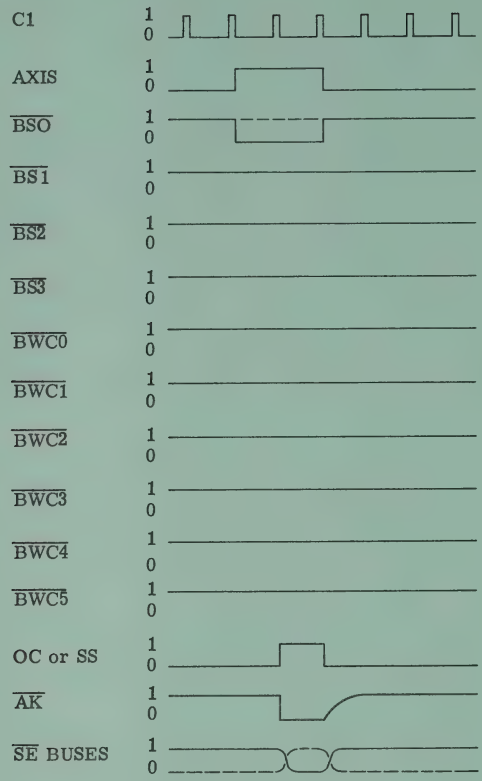


Figure 7.
TIMING FOR SS AND OC INSTRUCTION TO AN AXIS2* OR THC1* BOARD

NOTE: The system exchange buses vary with data. The board select lines correspond to the board being addressed.

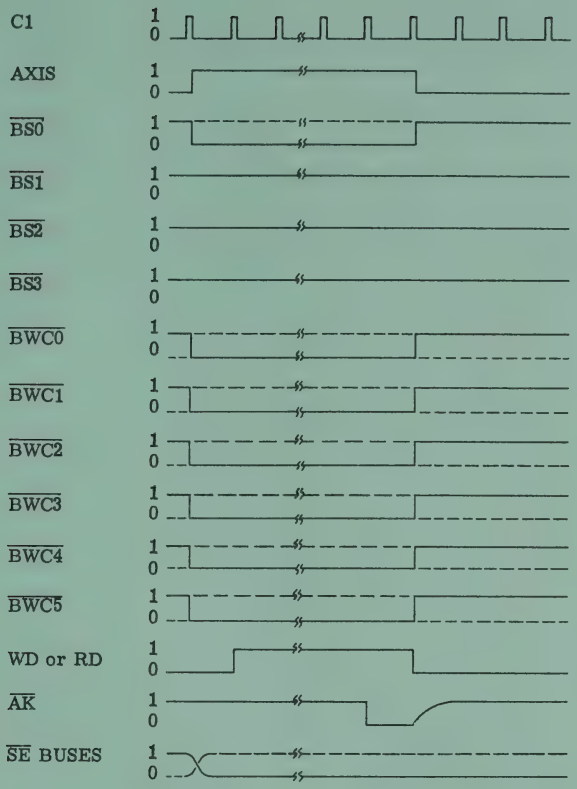


Figure 8.
TIMING FOR AN AXIS2* OR THC1* BOARD

NOTE: The timing for read data and write data instructions is identical in timing. The interruption shown occurs if the board is in a compution cycle that cannot be interrupted.

SECTION 3
USING THE SYSTEM SOFTWARE AS A TROUBLESHOOTING AID

When operating the Control with the System software, several error detection features are available. One feature consists of the error messages shown on the display.

ERROR MESSAGES SHOWN ON THE DISPLAY

These are described in the outline below. Other features are described on page 15.

MESSAGE	PROBABLE FAULT	TROUBLESHOOT BY:
LOSS OF FEEDBACK	There is a problem in the position feedback device, wiring between the AXIS2* board and the feedback device, or a fault on the AXIS2* board.	1. Check the position feedback. 2. Check the wiring between the AXIS2* and feedback. 3. Check the AXIS2* board.
OUT OF SYNC	Excessive velocity error has accumulated. If the problem occurred during threadcutting, the Gain controls in the Control or drive may be set too low, or there may be incorrect programming, or there may be a fault on the AXIS2* board. For normal operation and not threadcutting, error limit prevents reaching an out-of-sync condition.	1. Adjust the gain controls. 2. Check the AXIS2* board. 3. Check for runaway servos.
SPINDLE OVERSPEED	The spindle speed has exceeded a minimum value that has been set by the Machine Setup Data (MSD) section of the system tape. In the RPM mode the maximum speed cannot exceed 125% of the programmed value for a 800ms period of time or 137.5% for more than 100 milliseconds. In the CSS mode the maximum speed cannot exceed 125% of the constraint speed selected by the g92 command for a 800ms period of time or 137.5% for more than 100 milliseconds. When the spindle speed command is changed to a lower value, 6 seconds is allowed for the spindle to reach the new speed. The MSD may select the overspeed limits as 137.5% and 150% in place of 125% and 137.5%. If the error message occurs, the problem may be in the PERI1 or THC1 boards, the spindle drive or the spindle feedback system.	1. Check the PERI board. 2. Check the THC1*1 board. 3. Check the spindle drive.
MPE R3=XXXX PC=YYYY R2=ZZZZ	Incorrect parity has been received when data is read from a memory location.	Run the memory diagnostic software. Reload the executive tape.
FAK R3=XXXX PC=YYYY R2=ZZZZ	A board malfunction has prevented the board from acknowledging an instruction from the processor.	Run the diagnostic software.
READ ERROR	There is a reading error from tape while a part program tape or MSD is being read. The problem may be in the tape, the reader circuits, the TRAD2 board, or the PERI1 board.	1. Check the tape. 2. Check the reader circuits. 3. Check the PERI1 board.
MAAU FAULT	The MAAU1 board failed to successively complete an operation.	Use the diagnostic software to test the MAAU1 board.
SERVO FAULT	There is a problem in the servo.	Refer to the elementary diagrams (GEK-25295, reference sheet 902) for the 1050T or GEK-25281 reference sheet 923 for the 1054T for customer servo fault input (input points should be a logic-12V for normal operation).

NOTE: The 1054T control is equipped with 2 AXIS2 boards (designated AXIS2*1 and AXIS2*2) and 2 THC1 boards (designated THC1*1 and THC1*2).

OTHER ERROR DETECTION FEATURES

Test Indicator Lights Test

Depressing the Clear pushbutton causes all of the indicator lights to be turned on except the Control On, Control Off and Stop which are not tested.

Memory Check

Depressing the Clear pushbutton causes all memory locations to be read and the parity of the data contained to be checked. A memory failure may generally be detected by using this check. For further troubleshooting use the Memory Test Program.

Display of Memory Contents

The contents of any 4 successive memory locations may be displayed. This is especially useful in checking the status of I/O devices as described below. Select the address of the first of the 4 locations as follows:

1. Place the Display Override switch in the OVERRIDE position.

2. Place the Display Selector switch in the BUFFER position (32-character display) or PROGRAM position (256-character display).

3. Put the Address switch in any position except $, and set the Mode switch to MDI.

4. Press the minus sign key first and then key in the desired address. Each of the letters A, B, C, D, E or F may be keyed in by pressing first the plus sign and then the digit key 1, 2, 3, 4, 5 or 6. For example, the address 3E8B would be keyed in as 3, +5, 8, +2. This address and the contents of the 4 successive locations starting with this address are then displayed. Pressing the next button display the first address and contents of the next 4 locations.

Status of I/O Devices Check

The memory contains an image area where the state of all OD's and IF's are stored. By displaying the contents of the image area on the display, the state of all OD's and IF's can be determined.

If the Memory Display mode is selected (as described above) at any time after the power up sequence and before a different location has been selected, the address of the first location in the image area and the contents of the first 4 locations are displayed.

An example of the message on the display is: MEM 3E8B 12C1 0000 602C 0000, where 3E8B is the first location in the image area, the 12C1 is the hex data in the 3E8B location. Each group of 4 hex digits that follow 3E8B are in successive memory locations. Only the data in alternate memory locations is of interest. The data contained in locations 3E8B and 3E8D represents the states of the inputs to IFI32*1. To read the image of the next IF board, depress the Next pushbutton. Repeatedly depressing the Next pushbutton causes successive memory locations to be displayed, hence the entire image area may be observed.

Image Type	Board Type	Board Image Area Address* Word 1	Word 2
Input Filter	IFI32*1	3E8B	3E8D
	IFI32*2	3E8F	3E91
	IFI32*3	3E93	3E95
	IFI32*4	3E97	3E99
	IFI32*5	3E9B	3E9D
Output Driver	ODI32*1	3E9F	3EA1
	ODI32*2	3EA3	3EA5
	ODI32*3	3EA7	3EA9
Software Relay	SW*1	3EAB	3EAD
	SW*2	3EAF	3EB1
	SW*3	3EB3	3EB5

*Example addresses only. These may change from Control to Control.

Converting the hex data for IFI32*1 to a binary number that represents the states of the inputs may be done as follows: MEM 3E8B 12C1 0000 602C 0000

Hex Digit Value	1				2				C				1			
Binary Equivalent	0	0	0	1	0	0	1	0	1	1	0	0	0	0	0	1
Element No.	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Bit Number	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Byte Number	2								1							
Word Number	1															

Hex Digit Value	6				0				2				C			
Binary Equivalent	0	1	1	0	0	0	0	0	0	0	1	0	1	1	0	0
Element Number	32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17
Bit Number	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Byte Number	4								3							
Word Number	2															

A binary 0 indicates an open contact.

A binary 1 indicates a closed contact.

The bit numbers correspond with the system exchange bus signal names ($\overline{SE}$*). The byte numbers correspond with the byte of data selected in an IF board (signal $\overline{BWC0}$ selects byte 1).

Refer to the elementary diagram reference sheet 042, to determine which switches correspond to the filter elements.

Check the action of a switch by exercising the switch while monitoring the corresponding area on the display.

Determine the states of the other output drivers in a similar manner.

The display address (or location) of a 4-word image group in memory may change from Control to Control. However, the first 4-input filter word images will be first to be displayed when the display routine is entered immediately following the Power Up sequence. Follow the example shown to construct a load map.

Display Machine Position And Lag (Velocity Error)

Use the display to monitor the absolute position of a machine motion or the amount of velocity error as the motion is moving. This information is useful when adjusting the servos. For instance, make the position loop balance adjustment by adjusting the balance control until the lag goes to zero while the motion is not moving. Also, adjust the position loop gain for the correct amount of lag (velocity error) for a specified motion velocity. Make this adjustment while the motion is moving. Lag units are 0.0001 inch with Inch gearing and 0.002 mm with Metric gearing.

On Controls equipped with a 32-character display, place the display selector switch to ACTIVE and the display override switch to OVERRIDE. The display message is LAG X +00000 Z +00000. On Controls equipped with a 256-character display, place the Display selector switch in the STATUS position and the Display Override switch in the OVERRIDE position. The second and third lines on the display will indicate the lag and absolute position in the same format as described above.

SECTION 4
ERROR MESSAGES FROM DIAGNOSTIC SOFTWARE

In order to run the Diagnostic Software program it is necessary for certain hardware functions to be operable. In the event that one of these functions fails, an attempt is made to signal the operator that a failure has occurred. The error message may appear on the Display or the Control Panel as described below.

ERROR INDICATION OR MESSAGE	TEST	POSSIBLE CAUSE
Cycle Start and Option Stop lights flash simultaneously.	Central processor unit test program, Memory test program or System Diagnostic program).	The flashing lights indicate that the CPU has addressed the display, but the Display did not respond. 1. Failure of PERI1 board or wiring between PERI1 and the display. 2. Failure of the display. Refer to page 24 for the correct troubleshooting procedure.
NO ANSWER FROM IFI32*1	System Diagnostic Program.	The message indicates that the CPU has addressed the IFI32*1 board, but it did not respond. 1. Replace the IFI32*1 board. 2. Check signals $\overline{BS0}$, $\overline{BS1}$, $\overline{BS2}$, $\overline{BS3}$ and IFLTR on backplane pins B71, B72, B73, B74 and B77 respectively. Check for opens, shorts or faults being introduced by other boards. Use the loop on board test as described on page 21. While looping on the board use an oscilloscope to monitor the signals as shown in Figure 3, page 8. Note that a single byte instruction is being executed; the second byte will not be read as shown in the figure. 3. A fault on the CPU may prevent the CPU from driving the signal lines described above. The central processor test program may fail to reveal this type of failure. Replace the CPU board.
NO ANSWER FROM ODI32*1	System Diagnostic Program.	The CPU has addressed the ODI32*1 board but it did not respond. 1. Replace the ODI32*1 board. 2. Check signals BS0, BS1, BS2, BS3 and ODRVR on backplane pins B71, B72, B73, B74 and B76 respectively. Check for opens, shorts or faults being introduced by other boards. Use the loop-on-board test as described on page 22. While looping on the board, monitor the signals as shown in Figure 4, p. 9.

(Continued)

Error Indication or Message	Test	Possible Cause
NO ANSWER FROM ODI32 (Continued)	System Diagnostic Program.	3. A fault on the CPU may prevent the CPU from driving the signal lines described above. The central processor test program may fail to reveal this type of failure. Replace the CPU board.
PUSHBUTTON APPARENTLY DEPRESSED	System Diagnostic Program.	The CPU has received data from the IFI32*1 board indicating that one or more of the following encoded pushbuttons required for diagnostics is depressed. Next Cycle Start Optional Stop Clear + Incr. Keyboard (any button). 1. Use a voltmeter to check out pushbutton and wiring by monitoring pins U03 through U08 on IFI32*1. (Signals are also on DDM plug [pins 1 - 15] on back of operator's Control panel.) All pins must be between +11.0V and +12.0V. If they are not, contact must be closed or bad. Refer to the elementary diagrams, reference sheet 042. 2. If all inputs are at a high level, replace IFI32*1.
REAL TIME CLOCK NOT OPERATING.	Central Processor Test Program or System Diagnostic Program.	The real time clock is contained on the CPU board. This message indicates a failure on the CPU2 board. Replace the board.

SECTION 5
USING THE SYSTEM DIAGNOSTIC PROGRAM AS A TROUBLESHOOTING AID

The board exerciser, loop-on-board, loop-on-test when error is detected and operator-aided tests are described below.

BOARD EXERCISER

The System Diagnostic Program contains a board exerciser program which may be used to exercise any board in the Control. The control panel provides the means of sending data to or receiving data from a board. Instruction book GEK-36093, page 13, provides operating instructions. Four detailed examples follow: 2 for the 1050T and 2 for the 1054T.

The program can be used to check out the machine-mounted devices such as switches, relays and solenoids. Output Driver elements (ODI32) may be turned on and off, thus permitting checkout of the wiring and devices. Inputs to the input filters (IFI32) and wiring may be checked by operating the contacts and checking the data received from the IF board.

The first example shown below illustrates the procedure which would be followed while using the exerciser program to check out the x and z Lub solenoids on a machine. The second example illustrates how the program would be used to check out the x and z limit switches on a machine.

Example 1: 1050T

First determine which OD controls each solenoid. To do this, refer to the tables shown in the elementary diagrams, reference sheet 043 (GEK-25295 for 1050T). From the sheet we see that the x Lub solenoid is controlled by element No. 27 on ODI32*1 and that the z Lub solenoid is controlled by element No. 28 on ODI32*1. The first column shows that the address for the byte of data that controls elements 25 through 32 is 2210. The hex address is in the correct form to be entered into the program but the elements must be defined as hex digits.

To determine the hex data which is to be entered into DTA0000

Enter a 0 if the output driver is to be turned off.
Enter a 1 if the output driver is to be turned on.

Element No.	32	31	30	29	28	27	26	25
Enter 1 or 0	0	0	0	0	1	1	0	0
Hex Digit	0				C			

Since the OD board is controlled by writing data to it, we must determine the numerical code for a write word instruction. Information in GEK-36093, page 13, indicates that number 3 is a write word instruction. The first 5 steps listed below are setup procedures to enable the board exerciser.

PROCEDURE	MESSAGE DISPLAYED (ON THE TOP LINE)
1. Load the Diagnostic Test Program. Turn the Control off, then back on.	READY ENTER DATA
2. Enter 88 from the keyboard by depressing the 8 key twice; then depress the Next pushbutton.	MEMORY WRITE
3. Enter '00EF' from the keyboard by depressing the pushbuttons in the following sequence: 0, 0, +, 5, +, 6. Depress the Next pushbutton.	MEMORY WRITE 00EF 0000
4. Enter 1111 (may be any non-zero value) from the keyboard by depressing the 1 key 4 times.	MEMORY WRITE 00EF 0000 1111
5. Depress the Next pushbutton.	MEMORY WRITE 00EF 1111 1111
6. Depress the Optional Stop pushbutton.	READY ENTER DATA

(Continued)

PROCEDURE	MESSAGE DISPLAYED (ON THE TOP LINE)
7. Enter 77 from the keyboard by depressing the 7 key twice.	-
8. Depress the Next pushbutton.	OPOC BWC0000 DTA0000 and *ADR0070
9. Enter the address of ODI32*1 by depressing the digits 2210 on the keyboard.	OPOC BWC0000 DTA0000 *ADR2210
10. Depress the Next pushbutton, then the number 3 on the keyboard.	*OPWW BWC0000 DTA0000 ADR2210
11. Depress the Next pushbutton twice (bypassing BWC entry because it is contained in the board address). Then enter the hex data (000C) by depressing the 0 three times, + and 3 buttons on the keyboard.	OPWW BWC0000 *DTA000C ADR2210
12. Depress the Cycle Start pushbutton. The data is written out to the OD's and the designated output drivers turn on.	-
13. To turn the OD's off, depress the Next pushbutton and enter 0000 in *DTA using the same procedure described above. Then depress the Cycle Start pushbutton.	-

Example 1: 1054T

For the 1054T, refer to the tables shown in the elementary diagrams, reference sheet 44 (GEK-25281). From this sheet we see that the x Lube Solenoid is controlled by element 29, the z Lube Solenoid is controlled by element 30, the u Lube Solenoid is controlled by element 31, and the w Lube Solenoid is controlled by element 32. All are elements on the ODI32*3 board.

The first column shows that the address for the byte of data that controls elements 25 through 32 is 2210. The hex address is in the correct form to be entered into the program but the elements must be defined as hex digits.

To determine the hex data which is to be entered into DTA0000

Enter a 0 if the output driver is to be turned off.
Enter a 1 if the output driver is to be turned on.

Element No.	32	31	30	29	28	27	26	25
Enter 1 or 0	1	1	1	1	0	0	0	0
Hex Digit	F				0			

Since the OD board is controlled by writing data to it, we must determine the numerical code for a write word instruction. From GEK-36093, page 13, a number 3 indicates a write word instruction. The first 5 steps listed below are setup procedures to enable the board exerciser.

PROCEDURE	MESSAGE DISPLAYED (ON THE TOP LINE)
1. Load the Diagnostic Test Program. Turn the Control off, then back on.	READY ENTER DATA
2. Enter 88 from the keyboard by depressing the 8 key twice; then depress the Next pushbutton.	MEMORY WRITE
3. Enter '00EF' from the keyboard by depressing the pushbuttons in the following sequence: 0, 0, +, 5, +, 6. Depress the Next pushbutton.	MEMORY WRITE 00EF 0000
4. Enter 1111 (may be any non-zero value) from the keyboard by depressing the 1 key 4 times.	MEMORY WRITE 00EF 0000 1111
5. Depress the Next pushbutton.	MEMORY WRITE 00EF 1111 1111
6. Depress the Optional Stop pushbutton.	READY ENTER DATA
7. Enter 77 from the keyboard by depressing the 7 key twice.	-
8. Depress the Next pushbutton.	OPOC BWC0000 DTA0000 and *ADR0070
9. Enter the address of ODI32*3 by depressing the digits 2230 on the keyboard.	OPOC BWC0000 DTA0000 *ADR2230
10. Depress the Next pushbutton, then the number 3 on the keyboard.	*OPWW BWC0000 DTA0000 ADR2230
11. Depress the Next pushbutton twice (bypassing BWC entry because it is contained in the board address). Then enter the hex data (FO) by depressing the +6, and 0 buttons on the keyboard.	OPWW BWC0000 *DTA00FO ADR2230
12. Depress the Cycle Start pushbutton. The data is written out to the OD's and the designated output drivers turn on.	-
13. To turn the OD's off, depress the Next pushbutton and enter 0000 in *DTA using the same procedure described above. Then depress the Cycle Start pushbutton.	-

Example 2: 1050T

First determine which input filter (IF) each limit switch is connected to. To do this, refer to the tables shown in system elementary diagrams, reference sheet 042, GEK-25295. From this sheet we see that the x limit switch is connected to IF element number 6 on IFI32*2, and that the z limit switch is connected to IF element number 7 on IFI32*2. The first column in the table shows that the address for the byte of data that contains the IF's which are connected to the limit switches is 0720. The hex address is in the correct form to be entered into the program, but the hex data (DTA0000) received from the board must be interpreted.

Since the IF board is an input device, it is necessary to execute a read instruction to the board to determine the status of the inputs. A number 4 indicates a read word instruction. (See GEK-36093, page 13.) The first 5 steps of the following procedure are set-up procedures to enable the board exerciser.

PROCEDURE	DISPLAY MESSAGE (ON THE TOP LINE)
1. Load the Diagnostic Test Program. Turn the Control off, then back on.	READY ENTER DATA
2. Enter 88 from the keyboard by depressing the 8 key twice. Then depress the Next pushbutton.	MEMORY WRITE
3. Enter '00EF' from the keyboard by depressing the pushbutton in the following sequence: 0, 0, +, 5, +, 6.	MEMORY WRITE 00EF 0000
4. Enter 1111 from the keyboard by depressing the 1 key 4 times.	MEMORY WRITE 00EF 0000 1111
5. Depress the Next pushbutton.	MEMORY WIRTE 00EF 1111 1111
6. Depress the Optional Stop pushbutton.	READY ENTER DATA
7. Enter 77 from the Keyboard by depressing the 7 key twice.	-
8. Depress the Next pushbutton.	OPOC BWC000 DTA0000 *ADR0070
9. Enter the Address of IFI32*2 by depressing the digits 0720 on the keyboard.	OPOC BWC0000 DTA0000 *ADR0720
10. Depress the Next pushbutton, then the number 4 on the keyboard.	*OPRW BWC0000 DTA0000 ADR0720
11. Depress the Cycle Start pushbutton. The IF is read and the data received from it shown in the Display following the letters DTA. (Assuming that the switches connected to elements 2, 3, 4, 5, 6, and 7 are closed and the switches connecting element 1 and 8 are open.) Each time the Cycle Start pushbutton is depressed, the presently addressed IF board is read and the data displayed. The Cycle Start pushbutton may be depressed repeatedly until all 8 inputs have been tested by exercising the switch contacts where possible.	OPRW *BWC0000 DTA007E* ADR0720
12. To exit the exerciser program, depress the Optional Stop pushbutton.	READY ENTER DATA

*See information at the top of page 23.

To interpret the data, the hex digits following DTA must be converted to binary data.

A "0" indicates an open contact.

A "1" indicates a closed contact.

Hex Digit Value	0	0	7	E
Binary			0 1 1 1	1 1 1 0
Element Number			8 7 6 5	4 3 2 1
Bit Number			7 6 5 4	3 2 1 0

Ignore IF Boards

Example 2: 1054T

First determine which input filter (IF) each limit switch is connected to. To do this, refer to the tables shown in system elementary diagrams GEK-25281 reference sheet 042. From this sheet we see the x limit switch is connected to element numbers 29, the z limit switch is connected to element 30, the u limit switch is connected to element 31, and the w limit switch is connected to element 32 all on the IFI32*2 board.

The first column in the table shows that the address for the byte of data that contains the IF's which are connected to the limit switches is 2320. The hex address is in the correct form to be entered into the program, but the hex data (DTA0000) received from the board must be interpreted.

Since the IF board is an input device, it is necessary to execute a read instruction to the board to determine the status of the inputs. A number 4 indicates a read word instruction. (See GEK-36093, page 13.) The first 5 steps of the following procedure are set-up procedures to enable the board exerciser.

PROCEDURE	DISPLAY MESSAGE
1. Load the Diagnostic Test Program. Turn the Control off, then back on.	READY ENTER DATA
2. Enter 88 from the keyboard by depressing the 8 key twice. Then depress the Next pushbutton.	MEMORY WRITE
3. Enter '00EF' from the keyboard by depressing the pushbutton in the following sequence: 0, 0, +, 5, +, 6.	MEMORY WRITE 00EF 0000
4. Enter 1111 from the keyboard by depressing the 1 key 4 times.	MEMORY WRITE 00EF 0000 1111
5. Depress the Next pushbutton.	MEMORY WRITE 00EF 1111 1111
6. Depress the Optional Stop pushbutton.	READY ENTER DATA
7. Enter 77 from the Keyboard by depressing the 7 key twice.	-
8. Depress the Next pushbutton.	OPOC BWC000 DTA0000 *ADR0070
9. Enter the Address of IFI32*2 by depressing the digits 2320 on the keyboard.	OPOC BWC0000 DTA0000 *ADR2320

(Continued)

PROCEDURE	DISPLAY MESSAGE
10. Depress the Next pushbutton, then the number 4 on the keyboard.	*OPRW BWC0000 DTA0000 ADR2320
11. Depress the Cycle Start pushbutton. The IF is read and the data received from it shown in the Display following the letters DTA. (Assuming that the switches connected to elements 26, 27, 28, 29, 30, 31, and 32 are closed and the switch connected to element 25 is open.) Each time the Cycle Start pushbutton is depressed, the presently addressed IF board is read and the data displayed. The Cycle Start pushbutton may be depressed repeatedly until all 8 inputs have been tested by exercising the switch contacts where possible.	OPRW *BWC0000 DTA00FE ADR2320
12. To exit the exerciser program, depress the Optional Stop pushbutton.	READY ENTER DATA

To interpret the data, the hex digits following DTA must be converted to binary data.

A "0" indicates an open contact.

A "1" indicates a closed contact.

Hex Digit Value	0	0	F	E
Binary			1 1 1 1	1 1 1 0
Element Number			32 31 30 29	28 27 26 25
Bit Number			7 6 5 4	3 2 1 0

Ignore IF Boards

LOOP ON BOARD

When troubleshooting, it may be helpful to repeat the tests on a board at a faster rate so that signals may be observed on an oscilloscope. The loop-on-board repeatedly tests the same board without interrupting the sequence to test other boards. When observing signals on an oscilloscope, it may be desirable to inhibit the readout of errors and thus reduce the time required to repeat the tests. Mode 3 inhibits the readout of errors. Modes 1 and 3 may be entered simultaneously. Refer to GEK-36093, page 12 for a complete description of this feature.

Example:

Mode 1 is used for looping on the test of 1 board. The board slot number is entered to specify looping on a particular board. The following procedure should be followed for testing IFI32*2.

When the diagnostic software has been successfully loaded, the message on the display is READY ENTER DATA. Then:

1. Enter slot number 19 for IFI32*2 by depressing the 1 then the 9 pushbuttons on the keyboard. The message is:

19.

2. Depress the Next pushbutton. The message is:

19.

3. Enter 13 from the keyboard by depressing the 1, then 3 pushbuttons. The 13 indicates Modes 1 and 3, which is loop-on-board and suppresses error messages. The message display is:

19. 13

4. Depress the Cycle Start pushbutton and the test will run. Boards are tested in the order listed in the Configuration List (GEK-36092, page 4) until the specified board is reached. Then the board is tested repeatedly until Optional Stop is depressed which terminates the test. All of the boards that have a lower number than 19 are tested during the first pass. If a failure occurs on one of these lower numbered boards, the test halts and no error messages are displayed. Depress the Next pushbutton to acknowledge the failure and to continue testing. All error messages are suppressed and the Cycle Start light flashes on and off.

5. Depress the Optional Stop pushbutton to halt the test. The test may be terminated or new test instructions may be entered.

LOOP-ON-TEST WHEN ERROR IS DETECTED

Boards which have the capability built in (presently AXIS2*, MAAU1, and THC1*) respond to Mode 4. When Mode 4 is active and an error is encountered, the test goes into a small loop on the failed test. A thorough knowledge of the operation of these boards is necessary in order to troubleshoot them with this aid. Refer to GEK-36093, page 12 for a complete description of this feature.

OPERATOR-AIDED TESTS

The operator-aided tests provide a means of testing devices that require manual intervention. The tests are run by entering Mode 2 in the diagnostic test program. The tests are entered in the same sequence as listed below.

1. Load the diagnostic tape and the display message is READY ENTER DATA.

2. Depress the Next pushbutton.

3. Depress the 2 pushbutton on the keyboard.

4. Depress the Cycle Start pushbutton. The test begins to run and the Cycle Start and Optional Stop lights will alternately flash on and off.

5. Depressing the Cycle Start pushbutton causes the next test to run.

These tests are described below and run in the order listed.

1. Display Test (PERI1, AD32, AD256)
The display is tested by writing all permissible characters on the display. Verify that the characters are correct. Refer to GEK-36093, page 27 for a complete description of this test.

2. Sequence Number Readout Test (PERI1, AD32, AD256, SNRD1)
The sequence number readout is tested by writing all permissible numbers on the readout. Verify that the numbers are correct. Refer to GEK-36093, page 27 for a complete description of this test.

3. x and z Motion Resolvers (AXIS2*) test
To check the x and z resolvers, hand crank the motion while observing the position on the display. The 1054T has two more axes: u and w. To check the u and w resolvers, hand crank the motion while observing the position display. Refer to GEK-36093, page 19, test 80-81 for a complete description of this test.

The message on the display for the 1050T or 1054T is:

1	xxxxxxxx	xxxx	2	xxxxxxxx	xxxx
	Position	Disc.		Position	Disc.

4. Reversal Error Switches and MFO Pot. (THC1*1) Test △
Operate the switches while verifying their settings by the message on the display.

The message on the display will be

S RE	(XX)	Z RE	(XX)	MFO	(XX)
	Switch Setting		Switch Setting		Pot Setting

Starting with all switches closed, open the 7 DIP switches, one at a time, and the display for the switch positions should change per the following table:

Switch Number	Hex Value
1	01
2	02
3	04
4	08
5	10
6	20
7	40
All	7F

To test the MFO circuits, set the potentiometer to a position and then verify the position on the display. Refer to GEK-36093, page 23, test 22, for a complete description of these tests.

MFO SETTING	HEX DATA
0	00
20	28
40	50
60	78
80	A0
100	C8
120	F0

Potentiometer and dial tolerances cause the actual data to vary from that listed above.

5. Spindle Resolver (PERI1, THC1*1) Test
To test the spindle resolver, hand crank the spindle while monitoring the spindle angle on the display. Refer to GEK-36093, page 23, test 23, for a complete description of this test.

△ Note: The 1054T has 2 AXIS2 and 2 THC1 boards designated AXIS2*1, AXIS2*2, THC1*1 and THC1*2. The THC1*1 is only one associated with the reversal error test or the MFO Test.

The message on the display is:

"SPINDLE ANGLE 0XXX"
Angle In Hex (0000 to 0387)

Rotate the spindle smoothly and check that the hex valve also changes smoothly. Any "jumping" in valve indicates a problem in either the resolver or excitation driver.

SECTION 6
FAULT CONDITIONS AND POSSIBLE CAUSES

STOP LIGHTS ON

Following the initial loading of the system software, the Stop light will be turned on. Depressing the Control On pushbutton causes the light to turn off.

Any one of the following conditions causes the Stop light to remain on or to turn on.

1. The operation switch is in the TEST position.

2. A customer E-Stop interlock is open. Refer to the system elementaries, reference sheet 103.

3. Output Driver ODI32*1 element number 1 is turned off for one of the following reasons:

REASON	DISPLAY
A. Loss of the feedback signal to an AXIS2* board due to an open circuit. Pin B11 on the backplane goes to logic 0.	LOSS OF FEEDBACK
B. Out of sync signal from an AXIS2* board. Out of sync may be the result of excessive velocity error (a run-away servo). Pin B11 on the backplane goes to logic 0.	OUT OF SYNC
C. Excessive valve current on a hydraulic drive. Pin B11 on the backplane goes to logic 0.	NO DISPLAY
D. The Spindle overspeeds. Pin B11 on the backplane is not affected by this fault.	SPINDLE OVERSPEED
E. A memory parity error has occurred while reading data from a memory location. A message may or may not be displayed depending on which section of memory has failed. Pin B11 on the backplane is not affected.	MPE R3 = XXXX PC = YYYY R2 = ZZZZ
F. A board malfunction prevents it from acknowledging an instruction from the processor. If the PERI1 (readout section) fails, no message is displayed.	FAK R3 = XXXX PC = YYYY R2 = ZZZZ
G. A failure on the MAAU board prevents it from successfully completing an operation.	MAAU FAULT
H. A servo fault has occurred. Refer to elementary diagrams GEK-25295, reference sheet 902, for the 1050T or GEK-25281, reference sheet 923, for the 1054T circuit location.	SERVO FAULT
J. A processor error has occurred. An error message does not appear on the display. Pin B11 on the backplane goes to logic 0.	No display (Processor Error is on).

Output Driver element No. 1 on the ODI32*1 is provided with 2 inputs. These inputs are connected in a logical configuration such that either input may be used to turn the element off. One input is controlled through software and the other input connects to pin B11 on the backplane. A jumper connection on ODI32*1 connects pin B11 into the special input of element No. 1.

DISPLAY FAULT

Symptoms of a display failure may appear as incorrect characters, blank spaces in place of characters, a completely blank display or bright areas and dots.

CAUTION

The display may be damaged if the scanning sequence fails such that the dots glow brighter than normal. If this condition arises, remove the 32V and 250V power from the display before proceeding to troubleshoot.

Check the display as follows:

Measure DC Voltages to the Display.

32-Character Display (1050T only)

AD32

Pin	Volts
L -	+5V ± .25
O -	-12V ± .6
H -	+250V ± 12.5

Burrough Display

Pin	Volts
L -	+5V ± .25
D -	-12V ± .6
12 -	+250V ± 12.5

256-Character Display

AD256 (1PL)

Pin	Volts
L -	+5V ± .25
O -	-12V ± .6
M -	+32V ± 1.5
H -	-250V ± 12.5

Note: (1) On the 1054T control, any one of the AXIS2* boards, any one of the AHDS* (hydraulic option) or the THC1*1 board will cause Pin B11 to go to a logic 0. (2) The 256-Character Display is optional on the 1050T standard on 1054T controls.

Burroughs Display

Pin	Volts
39,78 -	+5V ± .25
38,76 -	+32V ± 1.5
35,70 -	-250V ± 12.5

2. Load the diagnostic tape as defined in GEK-36093.

The Cycle Start and Optional Stop lights flash simultaneously. The PERI1 board has not received a response from the display.

Monitor pin U37 and pin U19 on the PERI1 board. The presence of a logic 0 signal on pin U37 but not on U19 indicates a problem on the AD32 or AD256 board. If the logic 0 signal is not present on U37, the problem may be on the PERI1 board.

3. The Diagnostic tape loaded.

The tape appears to come to a normal stop but the display is blank.

If the Cycle Start and Optional Stop lights remain off, the display has returned a response to the PERI1 board. Troubleshoot as follows:

1. Turn the Control from off to on.
2. Depress the Next pushbutton.
3. Depress the 1, and 2 pushbuttons on the keyboard.
4. Depress the Cycle Start pushbutton.

If the Cycle Start and Optional Stop lights flash alternately, the test is running and data is being sent to the display continuously. Using an oscilloscope, monitor signals ROB0 through ROB7. If the logic 0 signals are present at the output of the PERI1 board, this indicates a problem in the AD32 or AD256 board. See Figure 9, page 29, for waveforms. If the signals are not present, the problem is in the PERI1 board.

4. Diagnostic Tape Loaded

Unintelligible characters are being displayed.

This indicates that incorrect data or addressing information is being sent to the AD32 or AD256 board. Troubleshoot this problem by monitoring the ROB0 through ROB7 signals with an oscilloscope. Analyze the problem by determining which address or data bit is at fault by observing the display pattern. Tables that define the address and character codes are shown on page 28.

Note:

Anytime the test is halted or the message on the display is not being changed, the last character sent to the display will be retained in the buffer on the PERI1 board.

Detailed information on Alphanumeric display is given in Chapter X.

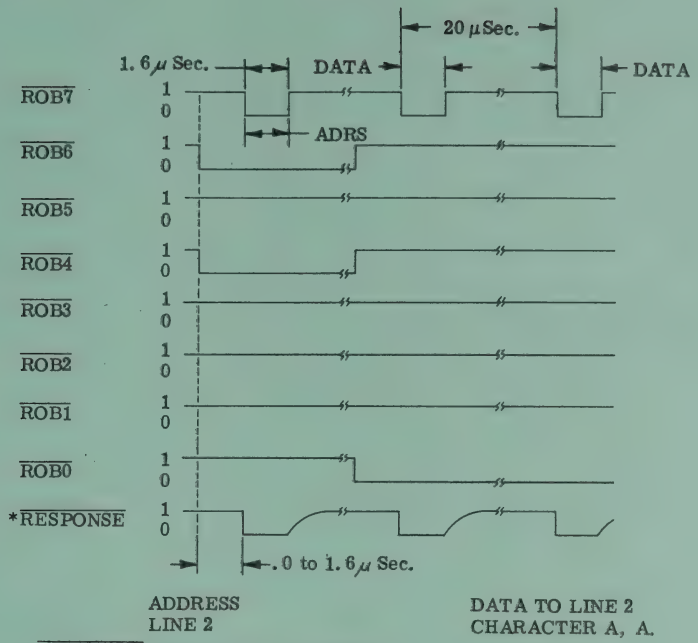
ROB BITS	$\overline{3}$	$\overline{2}$	$\overline{1}$	$\overline{0}$	COL.→ / ROW↓	1 0	1 1	0 0	0 1
						2	3	4	5
	0	0	0	0	0	SP	0	@	P
	0	0	0	1	1	!	1	A	Q
	0	0	1	0	2	"	2	B	R
	0	0	1	1	3	#	3	C	S
	0	1	0	0	4	$	4	D	T
	0	1	0	1	5	%	5	E	U
	0	1	1	0	6	&	6	F	V
	0	1	1	1	7	'	7	G	W
	1	0	0	0	8	(	8	H	X
	1	0	0	1	9	)	9	I	Y
	1	0	1	0	10	*	:	J	Z
	1	0	1	1	11	+	;	K	[
	1	1	0	0	12	,	<	L	~
	1	1	0	1	13	-	=	M	]
	1	1	1	0	14	.	>	N	{
	1	1	1	1	15	/	?	O	}

Table 1.
CODE CHART

NOTE: ROB bits 0 through 5 are signal names as shown in the elementary diagrams.

$\overline{ROB}$ BITS								DEVICE ADDRESSED
$\overline{7}$	$\overline{6}$	$\overline{5}$	$\overline{4}$	$\overline{3}$	$\overline{2}$	$\overline{1}$	$\overline{0}$	
0	0	1	1	1	0	X	X	Sequence Number Readout
0	0	1	1	1	1	X	X	256 Character Display — Line 1
0	0	1	1	0	1	X	X	256 Character Display — Line 2
0	0	1	0	1	1	X	X	256 Character Display — Line 3
0	0	1	0	0	1	X	X	256 Character Display — Line 4
0	0	0	1	1	1	X	X	256 Character Display — Line 5
0	0	0	1	0	1	X	X	256 Character Display — Line 6
0	0	0	0	1	1	X	X	256 Character Display — Line 7
0	0	0	0	0	1	X	X	256 Character Display — Line 8
0	0	X	X	X	1	X	X	32 Char. Display

Table 2.
ADDRESS CODES



*If $\overline{\text{RESPONSE}}$ jumper to 0V is removed.

Figure 9.
DISPLAY TIMING

NOTE: The waveforms shown above will be observed while running the System Diagnostic Test in Mode 2. The 20-microsecond period shown above is program dependent and will vary. The minimum period is 1.6 microseconds.

SECTION 7
TROUBLESHOOTING SEQUENCE CHARTS

The troubleshooting charts are divided into the following 5 groups.

	Page
Loss of Memory	31
Memory Power System	33
Power System	39
Processor Error Light On	43
Tapes Will Not Load	47

To use the charts, select the chart with the heading that best describes the Control malfunction. Begin in the block labled 1A. Each block defines certain tests and checks that you are to make. When the tests have been completed, arrows will direct you to the next group of tests that are contained in additional blocks.

Note that it is necessary to remain in one of the 5 groups while following the numbered arrows.

Since more than one fault condition can be present at a time, the charts may not apply directly to the symptons being observed. When there is such an occurence, use your judgment as to which path to follow. At times intermittent problems may not be identified the first time a series of checks are performed. Again, it is a matter of judgment in persuing the problem.

LOSS OF MEMORY

When the control is turned on and off, or the incoming AC power is interrupted, the CPU and REG8 generate signals that cause the memory boards (RAM*) to switch to a standby mode. If the timing of these signals are incorrect, memory may be lost. Use the following procedure to test for memory retention.

START

1A	CONTROL OFF	LOAD SYSTEM TAPE

Place the system tape in the reader.
Turn the keylock switch to the SOFTWARE LOAD position.
Depress the Store Program pushbutton.
Depress the Control On pushbutton while the Store Program pushbutton is depressed.
Release both buttons after the reader begins to run.
After loading, the readout will display one of the following messages. ZERO MACHINE or the software part no. "44C-----" if the Mode switch is in the Test position.

Yes

1B	CONTROL ON	DEPRESS CLEAR PUSHBUTTON

When the Clear pushbutton is depressed, all of the Control panel lights, except Control Off, turn on. The lights turn off when Clear is released.

The Processor Error light will be off.

Yes
1C

Page 31

1B
P. 29

IC	CONTROL ON	DEPRESS CONTROL OFF

Depress the Control Off pushbutton. Wait until the Control turns off, then depress the Control On pushbutton.

Momentarily depress the Clear pushbutton.
If the PROCESSOR ERROR light remains turned on following the above sequence a loss of memory has occurred.

The Processor Error light is OFF.

No. 2A
Page 32

Yes

1D	CONTROL ON	REMOVE AC POWER

Remove AC power for a short period of time.
Apply AC power. Then depress the Control On pushbutton.
Momentarily depress the Clear pushbutton.
If the Processor Error light remains On following the above sequence, a loss of memory has occurred.
The Processor Error light is OFF.

No. 3A
Page 32

Yes

This completes the test for memory retention. The test may be repeated to test for marginal or intermittent conditions.

1C
P. 29

2A	CONTROL ON	CHECK TIMING

When the Control is turned on and off it is essential that the correct timing be maintained between the following signals:

+5VL	(CPU, L05)
ALLPWRUP	(REG8, 3TB-D)
PWRFAIL	(REG8, 3TB-B or C)
HALT	(CPU, B15)

Figure 10A (page 32) illustrates the correct timing of the signals. If the timing of any one of these signals is incorrect, check the source of that signal. The source is noted inside of the parenthesis above.

Correct the problem.

1C
Page 31

3A	CONTROL ON	CHECK REG8

The loss of AC power is detected by the REG8 board. Measure REG8 input voltage. +17.6V 2TB-A (+16.0 to +20.0V). See Figure 10B (page 32). Check the timing of the following signals.

ACOFF	REG8 Test Socket-16
+5VL	(CPU, L05)
PWRFAIL	(REG8, 3TB-B)
HALT	(CPU, B15)

Figure 10B illustrates the correct timing of the signals.

Correct the problem.

1C
Page 31

MEMORY POWER SYSTEM

A fault in the memory power system may not be obvious at first since the fault may inhibit all normal operations of the Control.

The Memory Power Supply DC output voltages (+12 volt output) may not be correct when AC power is first applied to the Control or the battery switch closed prior to turning on the Control the first time.

The reason for this condition is that the memory boards (RAM*) will require more than a normal amount of power until they have been initilized. The RAM* boards are initilized automatically the first time the Control is turned on following a completely powered down condition. Power from both the Memory Power Supply and Main Logic Power Supply are required by the RAM* boards for initilization.

START

1A | CONTROL ON | MEASURE DC VOLTAGES

Refer to reference sheets 102A, 102B, or 102C. Switch SW1 closed.
Measure REG8 input voltages.
+15V 2TB-C (+15.75 to +17.0V) (VB)
+17.6V 2TB-A (+16.0 to +22.0V) (VPS)
(See Figure 11, page 36)
Voltages normal.

No. 2A → Page 35

Yes

1B | CONTROL ON | MEASURE DC VOLTAGES

Measure memory supply voltages on REG8.
+5V 1TB-A, 1TB-B (+4.9 to +5.15V)
+12V 1TB-E, 1TB-F (±11.75 to +12.25V)
-5V 1TB-L, 1TB-M (-4.9 to -5.15V)
+4.75V +5.2 (+4.73 to 4.77)
Voltages normal.

No. 3A → Page 35

Yes

1C | CONTROL ON | MEASURE DC VOLTAGES

Measure level of logic signals on REG8.
Input Signals.
ALLPWRUP 3TB-D (+4.75 to +5.25V)
RESET 3TB-E (+10 to +11.5V)
+5VL 3TB-H (+4.75 to +5.25V)
Output Signals
PWRFAIL 3TB-B (0V to +0.4V)
PWRFAIL 3TB-C (0V to +0.4V)
*ALLMEMLOSS 3TB-F (+4.25 to +5.25V)
*Requires terminal 3TB-E (RESET) to be momentarily connected to 0V if the system software is not running. This clears the ALLMEMLOSS Latch on REG8.
Signal level is 4.75V at TS-2.

No. 3G → Page 36

Yes → Page 33
ID

1C
P.31

1D | CONTROL ON | MEASURE DC VOLTAGES

Measure battery charger output voltage.
PS102
+13.65 223TB-A (+13.60 to 13.70V)
+13.65 223TB-B (+13.60 to 13.70V)
+13.65 223TB-C (+13.60 to 13.70V)
+13.65 223TB-D (+13.60 to 13.70V)

No. 4A → Page 37

Yes

1E | AC POWER OFF | MEASURE DC VOLTAGES

Check operation of supply from battery input. Measure memory supply voltage on REG8.
+5 1TB-A, 1TB-B (+4.9 to +5.15V)
+12 1TB-E, 1TB-F (+11.75 to +12.25V)
-5 1TB-L, 1TB-M (-4.9 to -5.15V)
Voltages Normal.

No. 5A → Page 37

Yes

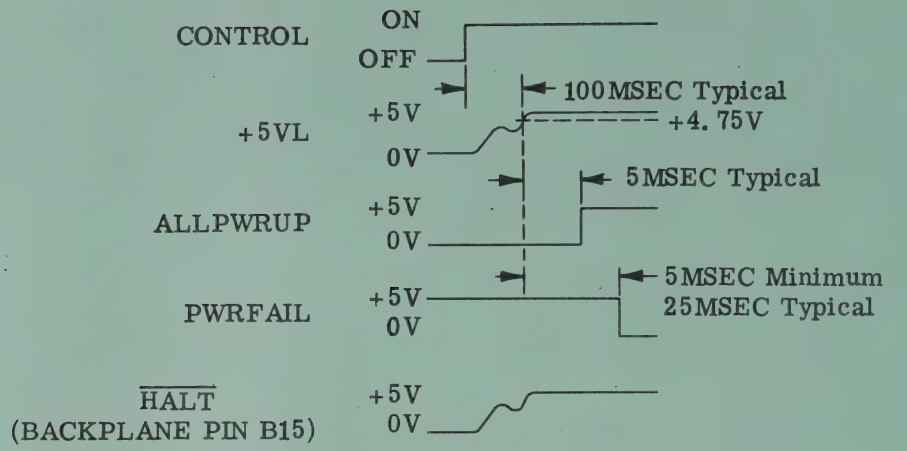
1F | AC POWER OFF | MEASURE DC VOLTAGES

Measure level of logic signals on REG8A.
PWRFAIL 3TB-B (+4.25 to +5.25V)
PWRFAIL 3TB-C (+4.25 to +5.25V)
ALLMEMLOSS 3TB-F (+4.25 to +5.25V)
Signals normal.

No. 3G → Page 36

Yes

This completes the tests on the Memory Power System.



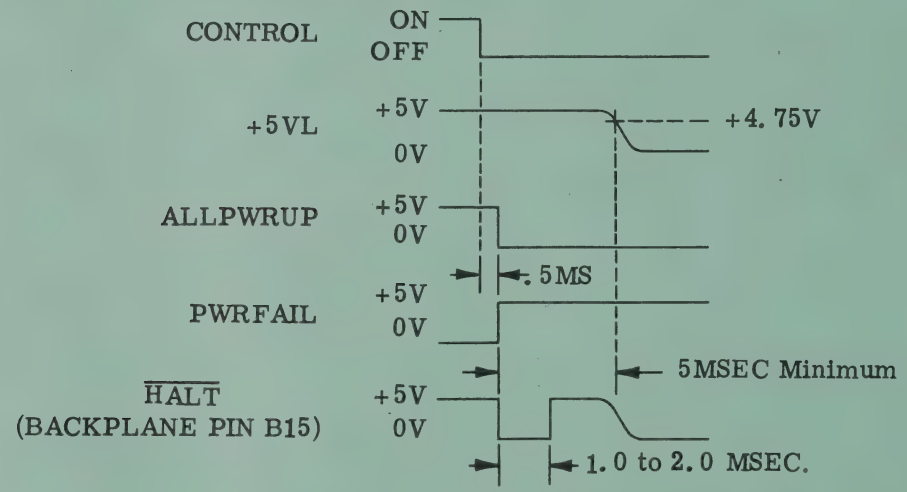
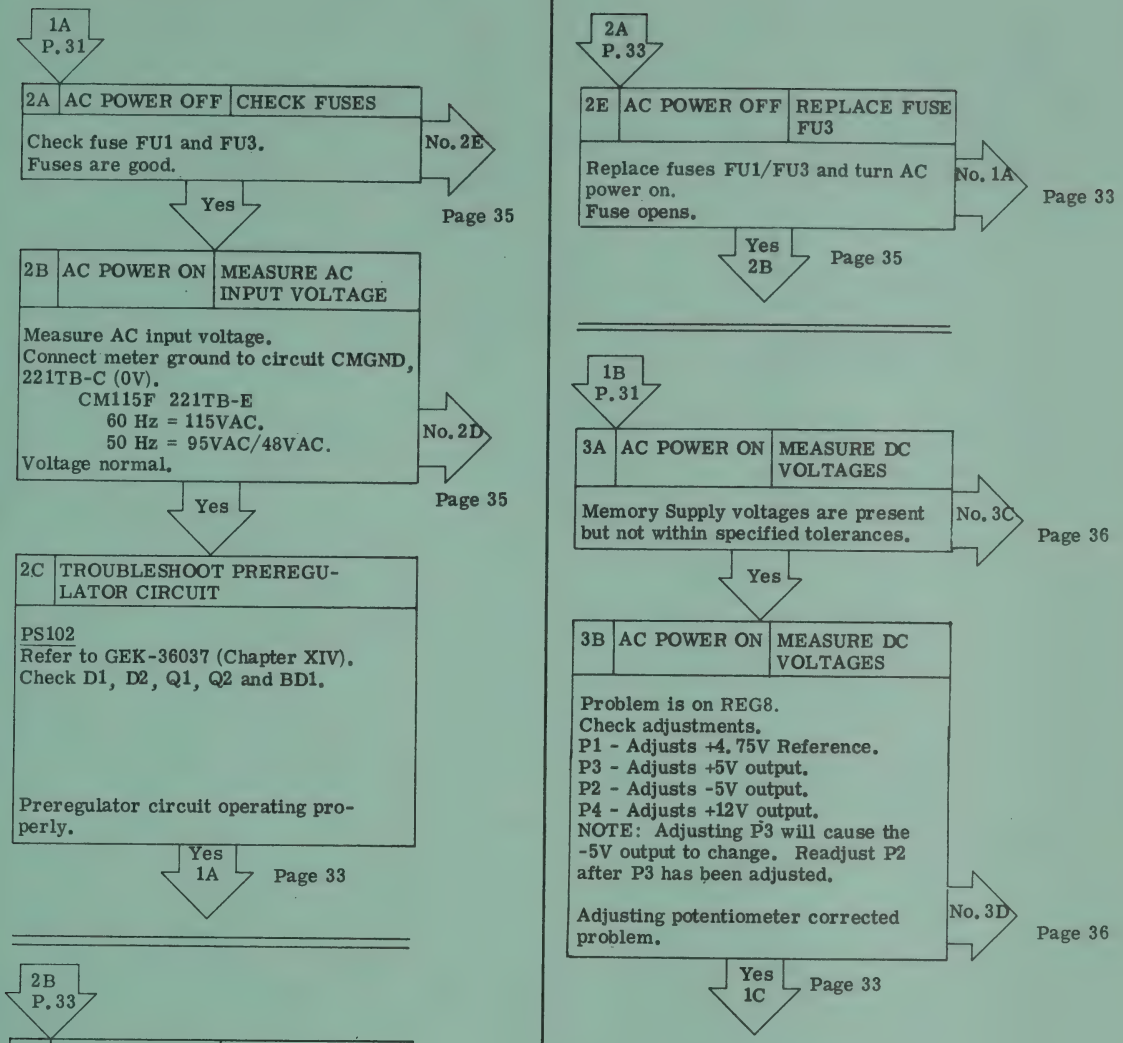
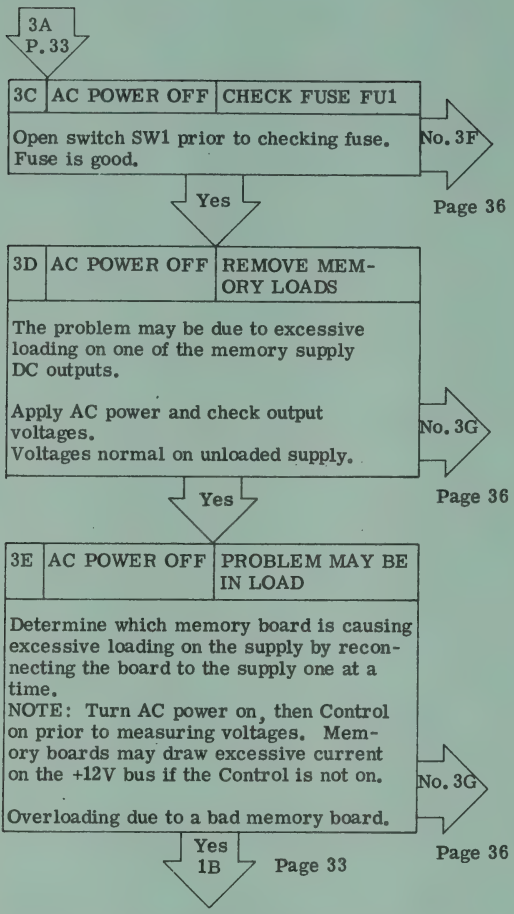
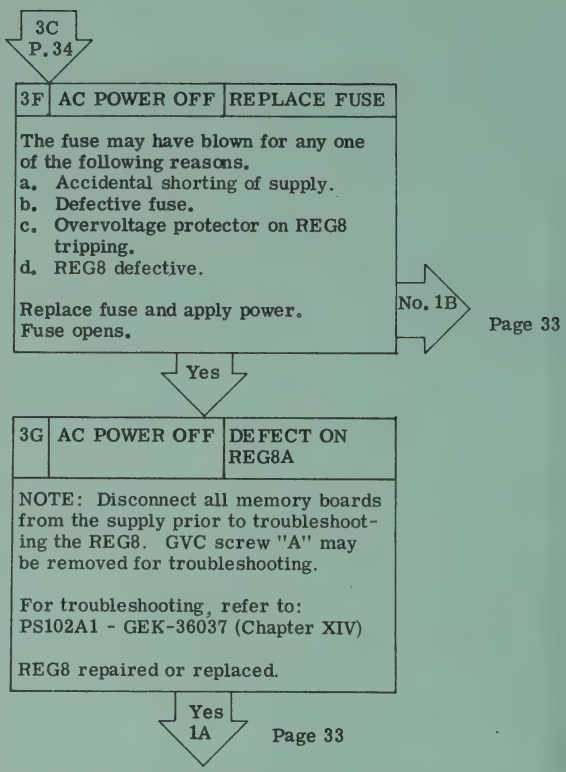


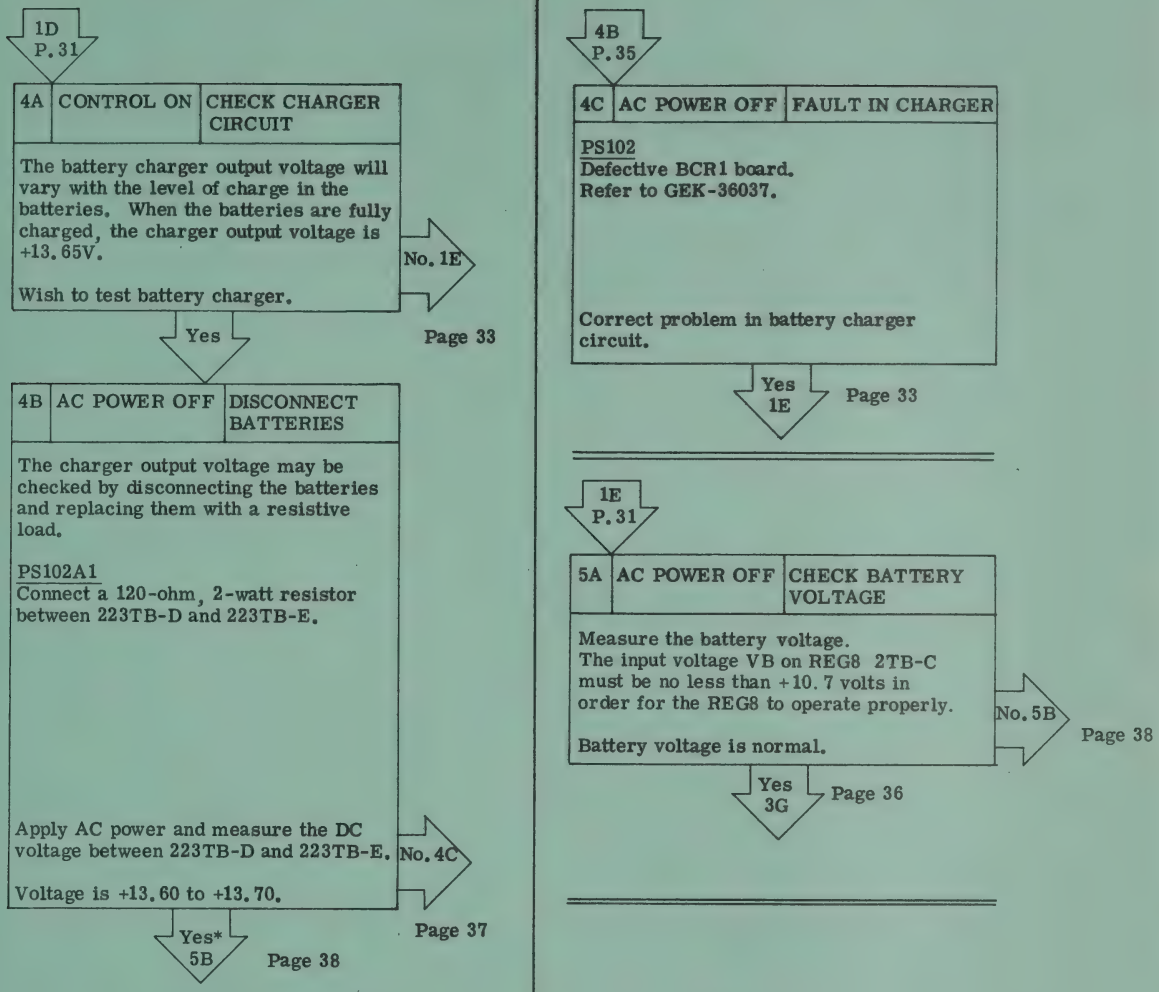
Figure 10A and 10B
POWER OFF SEQUENCE

Ref. 48-33
Ref. 48-33A


1A
P. 31
2A
AC POWER OFF
CHECK FUSES
Check fuse FU1 and FU3.
Fuses are good.
No. 2E
Page 35
Yes
2B
AC POWER ON
MEASURE AC INPUT VOLTAGE
Measure AC input voltage.
Connect meter ground to circuit CMGND, 221TB-C (0V).
CM115F 221TB-E
60 Hz = 115VAC.
50 Hz = 95VAC/48VAC.
Voltage normal.
No. 2D
Page 35
Yes
2C
TROUBLESHOOT PREREGULATOR CIRCUIT
PS102
Refer to GEK-36037 (Chapter XIV).
Check D1, D2, Q1, Q2 and BD1.
Preregulator circuit operating properly.
Yes
1A
Page 33
2B
P. 33
2D
AC POWER OFF
CHECK CONTROL WIRING
Problem is in the Control's power system. Troubleshoot that section.
Problem corrected.
2B
Page 35
2A
P. 33
2E
AC POWER OFF
REPLACE FUSE FU3
Replace fuses FU1/FU3 and turn AC power on.
Fuse opens.
No. 1A
Page 33
Yes
2B
Page 35
1B
P. 31
3A
AC POWER ON
MEASURE DC VOLTAGES
Memory Supply voltages are present but not within specified tolerances.
No. 3C
Page 36
Yes
3B
AC POWER ON
MEASURE DC VOLTAGES
Problem is on REG8.
Check adjustments.
P1 - Adjusts +4.75V Reference.
P3 - Adjusts +5V output.
P2 - Adjusts -5V output.
P4 - Adjusts +12V output.
NOTE: Adjusting P3 will cause the -5V output to change. Readjust P2 after P3 has been adjusted.
Adjusting potentiometer corrected problem.
No. 3D
Page 36
Yes
1C
Page 33


3A
P. 33
3C | AC POWER OFF | CHECK FUSE FU1
Open switch SW1 prior to checking fuse.
Fuse is good.
No. 3F
Page 36
Yes
3D | AC POWER OFF | REMOVE MEMORY LOADS
The problem may be due to excessive loading on one of the memory supply DC outputs.
Apply AC power and check output voltages.
Voltages normal on unloaded supply.
No. 3G
Page 36
Yes
3E | AC POWER OFF | PROBLEM MAY BE IN LOAD
Determine which memory board is causing excessive loading on the supply by reconnecting the board to the supply one at a time.
NOTE: Turn AC power on, then Control on prior to measuring voltages. Memory boards may draw excessive current on the +12V bus if the Control is not on.
Overloading due to a bad memory board.
No. 3G
Page 36
Yes
1B
Page 33


3C
P. 34
3F | AC POWER OFF | REPLACE FUSE
The fuse may have blown for any one of the following reasons.
a. Accidental shorting of supply.
b. Defective fuse.
c. Overvoltage protector on REG8 tripping.
d. REG8 defective.
Replace fuse and apply power.
Fuse opens.
No. 1B
Page 33
Yes
3G | AC POWER OFF | DEFECT ON REG8A
NOTE: Disconnect all memory boards from the supply prior to troubleshooting the REG8. GVC screw "A" may be removed for troubleshooting.
For troubleshooting, refer to:
PS102A1 - GEK-36037 (Chapter XIV)
REG8 repaired or replaced.
Yes
1A
Page 33



*Reconnect batteries.

5A
P. 35

5B	AC POWER OFF	BATTERY NOT CHARGED

The problem may be due to a bad battery or defective charger.

Check charger as defined in GEK-36037 (Chapter XIV) for the PS102.

Battery replaced or charger repaired.

Yes
1E

Page 33

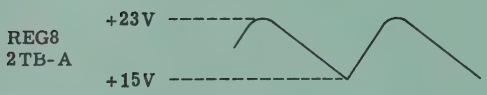


FIGURE 11
SIGNAL VPS

POWER SYSTEM

NOTE: Before you proceed with the following checks, refer to GEK-25295 (1050T) or GEK-25281 (1054T) reference sheets 100, 101, and 102 to familiarize yourself with the power system.

START

1A | AC POWER ON | MEASURE AC VOLTAGE

Refer to reference sheets 100, 101 and 102.
Measure AC Input voltage.
Measure AC voltages on the secondary of transformer 1T.
Voltage will be within -10% to +15%.

→ No. 2A Page 39

Yes

1B | AC POWER ON | MEASURE DC VOLTAGE

Refer to reference sheets 100 and 101.
Measure DC voltages at the following points:

+25V 505TB-T	(+23 to +27V)
+25VC 3TB-K	(+23 to +27V)
+40V 506TB-R	(+36 to +44V)
+5.7V 603TB-E	(+5.2 to +6.0V)
+5.7VC 3TB-L	(+5.2 to +6.0V)

→ No. 3A Page 40

Yes

1C | AC POWER ON | DEPRESS CONTROL ON PUSHBUTTON

Control On pushbutton will light.
Fans start.
Logic power supply turns on.

→ No. 4A Page 41

Yes

1D | AC POWER ON | MEASURE LOGIC VOLTAGES

Refer to reference sheets 101-102.
Measure logic bus voltages.
Measured at logic rack bus conn.

+5V	Bus Bar (+4.85 to +5.25V)
+12V	Bus Bar (+11.65 to +12.35V)
-12V	Bus Bar (-11.65 to -12.35V)
+12VC	7TB-S (+11.65 to +12.35V)
-12VC	7TB-T (-11.65 to -12.35V)

→ No. 4C Page 41

Yes

This completes the tests on the Power System.

1A
P. 37

2A | AC POWER OFF | CHECK FUSES

Input fuses are good.

→ No. 2E Page 40

Yes

2B | AC POWER OFF | WIRING CHECK

Check jumper connections on the primary of transformer 1T.

→ No. 2F Page 40

Yes

2C | AC POWER OFF | REMOVE LOADS

An undervoltage condition on any transformer secondary winding may be due to an overload condition on that circuit.
Remove loads by removing fuses (25FU, 25CFU, 5.7FU and 5.7CFU).

Recheck AC voltages.

→ No. 3A Page 40

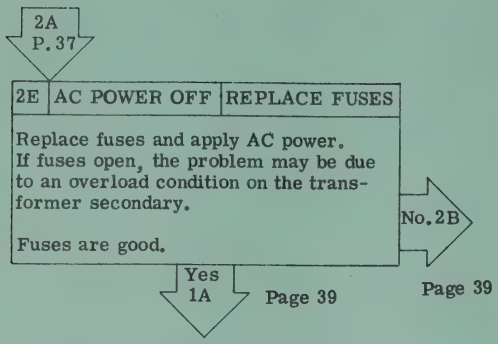
Yes

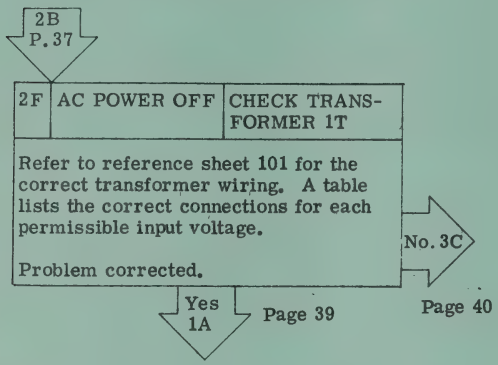
2D | AC POWER OFF | LOCATE FAULTY CIRCUIT

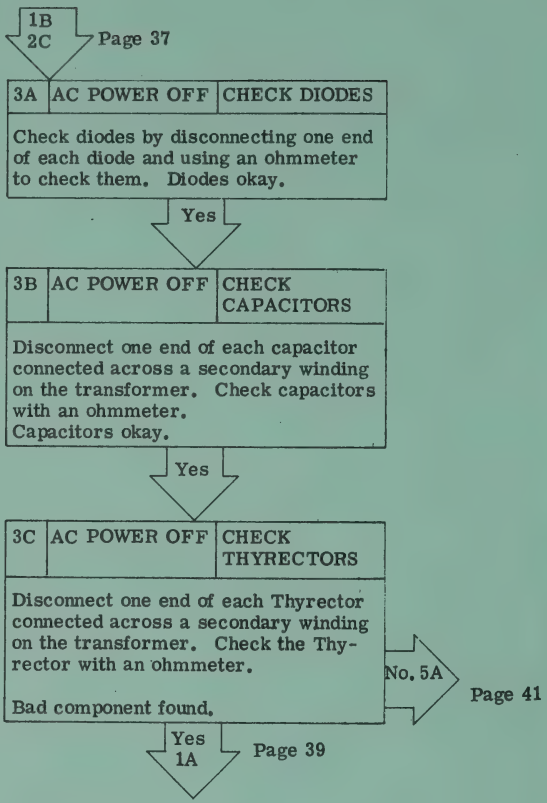
If the AC voltages check normal with the loads removed, the problem is due to excessive loading. Determine which circuit is at fault and troubleshoot that circuit. Look for shorted connections and components that have discolored due to overheating.

Correct problem.

1A
Page 39


2A
P. 37
2E
AC POWER OFF
REPLACE FUSES
Replace fuses and apply AC power.
If fuses open, the problem may be due to an overload condition on the transformer secondary.
Fuses are good.
No. 2B
Page 39
Yes
1A
Page 39


2B
P. 37
2F
AC POWER OFF
CHECK TRANSFORMER 1T
Refer to reference sheet 101 for the correct transformer wiring. A table lists the correct connections for each permissible input voltage.
Problem corrected.
No. 3C
Page 40
Yes
1A
Page 39


1B
2C
Page 37
3A
AC POWER OFF
CHECK DIODES
Check diodes by disconnecting one end of each diode and using an ohmmeter to check them. Diodes okay.
Yes
3B
AC POWER OFF
CHECK CAPACITORS
Disconnect one end of each capacitor connected across a secondary winding on the transformer. Check capacitors with an ohmmeter.
Capacitors okay.
Yes
3C
AC POWER OFF
CHECK THYRECTORS
Disconnect one end of each Thyrector connected across a secondary winding on the transformer. Check the Thyrector with an ohmmeter.
Bad component found.
No. 5A
Page 41
Yes
1A
Page 39

1C
P. 37

4A	AC POWER ON	CHECK MAGNETICS

Depress the Control On pushbutton.
See Figure 12 (page 42) for the correct timing sequence for the relay circuitry.

Timing checks okay.

No. 4D

Page 41

Yes

4B	AC POWER ON	CHECK CIRCUIT CM155

Depress the Control On pushbutton.
Monitor circuit CM155 with an oscilloscope. See Figure 12 (page 42).

No. 4E

Page 39

Yes

4C	AC POWER ON	CHECK DC POWER SUPPLY

WARNING
When troubleshooting the DC power supplies, excessive output voltages may damage the logic circuits. Disconnect the logic load from the supply. Refer to Chapter XIV when troubleshooting the supplies.
Correct supply problems.

1D
Page 39

4A
P. 39

4D	AC POWER OFF	CHECK RELAY CIRCUITRY

Check the relays and associated components by using an ohmmeter.

Check relay wiring for broken or loose connections.

Check customer interlocks.
Problem found.

No. 4B

Page 41

Yes
1D
Page 39

4B
P. 39

4E	AC POWER ON	CHECK PROTECTOR CIRCUITS

The Control may be tripping out due to an overvoltage or undervoltage condition in the power supplied.
Check REG9 board. (4PL-10 should be logic 0.)
Check crowbar protector on OVP1 board.
Problem corrected.

No. 4C

Page 41

Yes
1D
Page 39

3C
P. 38

5A	AC POWER OFF	REPLACE TRANSFORMER 1T

If all other checks fail to reveal a problem, the transformer is probably bad. This may be confirmed by using an ohmmeter to check the transformer for open or shorted windings.

1A
Page 39

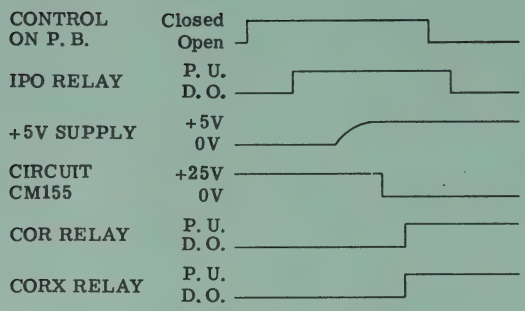


Figure 12A.
CONTROL ON SEQUENCE

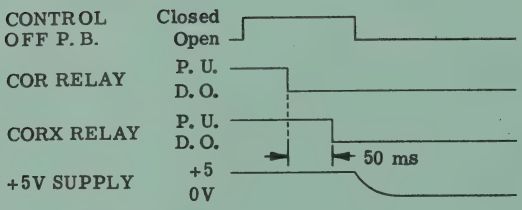


Figure 12B.
CONTROL OFF SEQUENCE

PROCESSOR ERROR LIGHT IS ON

NOTE: This light being on does not necessarily indicate a hardware failure. The light may be turned on for anyone of the following reasons:

1. All memory loss. (REG8)
2. Watchdog timer times out. (CPU)
3. Memory parity error. (RAM1)
4. Loss of C1 clock (CPU)

START

1A	CONTROL ON	LOAD SYSTEM SOFTWARE

It is normal for the Processor Error light to turn on when the Control is first turned on from a completely powered down condition, battery switch open.

Software loads and the Processor Error light turns off.

No. 1B — Page 43

Yes

The System is operating normally.

1A
P. 41

1B	CONTROL ON	SYSTEM SOFTWARE LOADED

Software loads and the Processor Error light remains on.

No. 1A — Page 43

Yes

1C	CONTROL OFF	CHECK ODI32*1 BOARD

Check jumper connections between Pins C01-A and C01-H on ODI32*1.

Jumper connections are correct.

Yes

1D	CONTROL ON	CHECK SIGNAL $\overline{\text{COMPERR}}$

Monitor signal $\overline{\text{COMPERR}}$ on pin B09 on the backplane.

$\overline{\text{COMPERR}}$ is logic 0.

No. 3A — Page 44

Yes

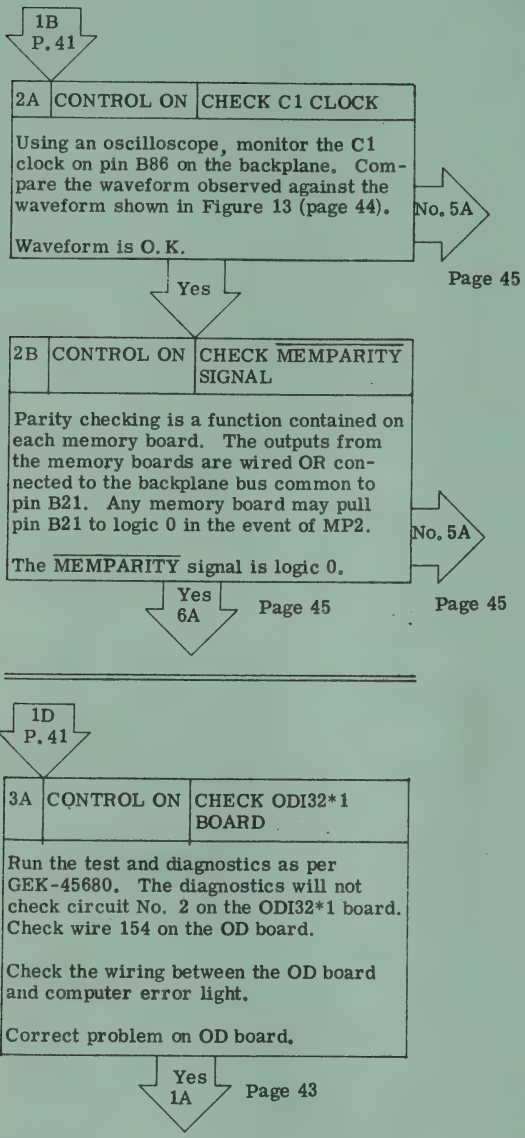
1E	CONTROL ON	CHECK $\overline{\text{ALLMEM-LOSS}}$ SIGNAL

If the System software tape loads but the Processor Error light remains on, the problem may be due to the $\overline{\text{ALLMEMLOSS}}$ signal being logic 0. Monitor the signal on pin L02 on the CPU2 board.

The $\overline{\text{ALLMEMLOSS}}$ signal is logic 0.

No. 2B — Page 44

Yes
4A — Page 45


1B
P. 41
2A
CONTROL ON
CHECK C1 CLOCK
Using an oscilloscope, monitor the C1 clock on pin B86 on the backplane. Compare the waveform observed against the waveform shown in Figure 13 (page 44).
Waveform is O. K.
No. 5A
Page 45
Yes
2B
CONTROL ON
CHECK MEMPARITY SIGNAL
Parity checking is a function contained on each memory board. The outputs from the memory boards are wired OR connected to the backplane bus common to pin B21. Any memory board may pull pin B21 to logic 0 in the event of MP2.
The MEMPARITY signal is logic 0.
No. 5A
Page 45
Yes
6A
Page 45
1D
P. 41
3A
CONTROL ON
CHECK ODI32*1 BOARD
Run the test and diagnostics as per GEK-45680. The diagnostics will not check circuit No. 2 on the ODI32*1 board. Check wire 154 on the OD board.
Check the wiring between the OD board and computer error light.
Correct problem on OD board.
Yes
1A
Page 43

1E
P. 41

4A	CONTROL ON	CHECK REG8

The $\overline{\text{ALLMEMLOSS}}$ signal is the output of a latch circuit on the REG8 board. The latch sets when the batteries have been discharged or all power in the Control has been turned off. The latch resets through software by energizing an output driver that momentarily pulls terminal 3TB-E on REG8 to 0V.

Momentarily connect terminal 3TB-E on REG8 to 0V.

The $\overline{\text{ALLMEMLOSS}}$ signal (3TB-E) goes to logic 1.

No. 7A

Page 46

Yes

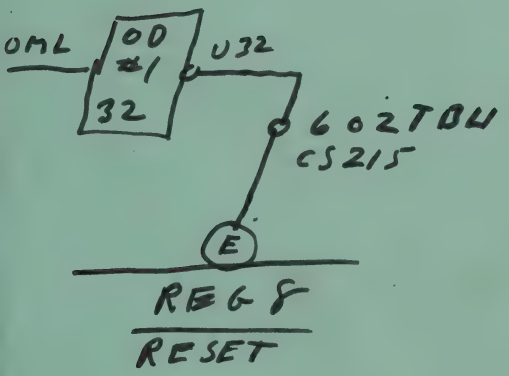
4B	CONTROL ON	CHECK ODI32*1

Check wiring between the OD and REG8 boards. Run the Test and Diagnostics to test the OD board. Correct the fault.

OD #1
U32

Yes
1A

Page 43



2A
2B

Page 42

5A	CONTROL OFF	CHECK CPU2 BOARD

The problem may be due to a bad component on the CPU board or a fault on the backplane buses. Check the backplane and other boards for a fault condition.

Repair faults and/or replace CPU.

Yes
1A

Page 43

2B
P. 42

6A	CONTROL OFF	CHECK MEMORY BOARDS

There are 2 types of failures that will cause a memory parity error.

1. A bad component in the parity checking circuit on the memory board.
2. Reading data from a memory location that has failed or has not been previously written to.

Locate the bad board by using the Test and Diagnostic programs. Replace or repair the bad memory board.

Yes
1A

Page 43

4A
P. 43

7A	CONTROL OFF	CHECK REG8
Refer to GEK-36037 (Chapter XIV) for a description of the REG8 board. **Repair or replace the REG8A.**		

1A
Page 43

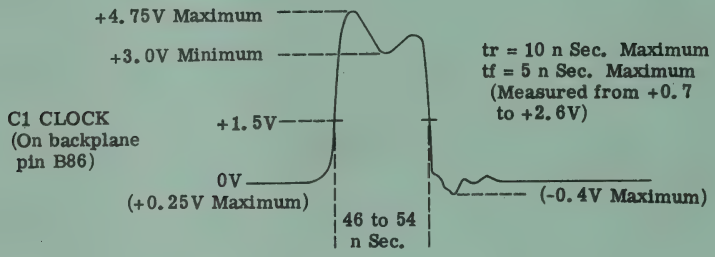


Figure 13.

SYSTEM DIAGNOSTIC SOFTWARE TAPES WILL NOT LOAD

Many times when a tape fails to load it will be found that either a switch is in the incorrect position or the tape is faulty.

START

1A	CONTROL OFF	LOAD DIAGNOSTIC TAPE

Place the Diagnostic tape in the reader.

Turn the keylock switch to the SOFTWARE LOAD position and the Operation switch to the TEST position. Depress the Store Program pushbutton. Depress the Control On pushbutton while the Store Program button is depressed.

Release both buttons after the reader begins to read.

The tape reader runs.

No. 2A

Page 47

Yes

1B	CONTROL ON	CHECK DISPLAY

The tape reader stops at the end of the test program and the test begins to run. The first test loaded is the CPU test program. Refer to GEK-36093 for a complete description of this test. The reader stops and a message is displayed after several seconds.

No. 7A

Page 51

Yes

The tape reader is operating normally.

2A	CONTROL ON	CHECK POWER SUPPLIES

An out of tolerance voltage on either a logic power bus or memory power bus may prevent proper operation of the Control.

Check logic power bus voltages.
Check memory power bus voltages.
Check PWRFAIL signal (+.04V Max.) from the memory power supply.
Voltages are normal.

No. 3A

Page 48

Yes

2B	CONTROL ON	CHECK SWITCHES

Check the Software Load keylock switch and the Store Program pushbutton switch for proper operation. Check the wiring between the switches and IF*2 board, elements 1 and 20.
Refer to GEK-25295 (1050T) or GEK-25281 (1054T) reference sheet 109.
Switches and wiring are okay.

No. 3A

Page 48

Yes

2C	CONTROL ON	CHECK SIGNAL LEVELS

The problem may be isolated to the Control logic or tape reader circuits by monitoring the interface signals. The signal levels should be as follows: (721TB located below tape reader)

$\overline{\text{INHIBIT}}$ U09	721TB-A (high level)	4.91
$\overline{\text{FASTRWD}}$ U04	721TB-C (high level)	7.19
$\overline{\text{FWD}}$ U08	721TB-D (+0.4V Max.)	.02
$\overline{\text{RWD}}$ U31	721TB-E (high level)	10.47

The amplitude of the high level signals depends on the type of tape reader used. The high level will normally be between +12 and +18 volts.

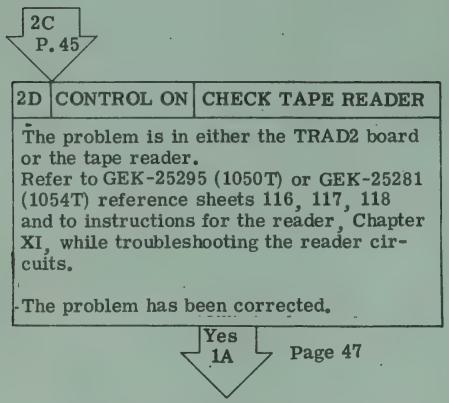
Signal levels are correct.

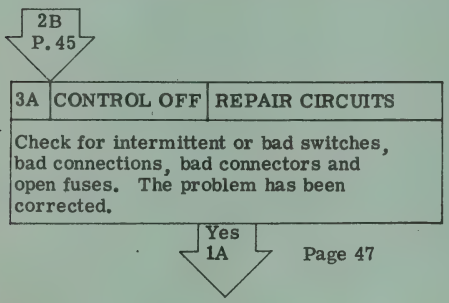
No. 4A

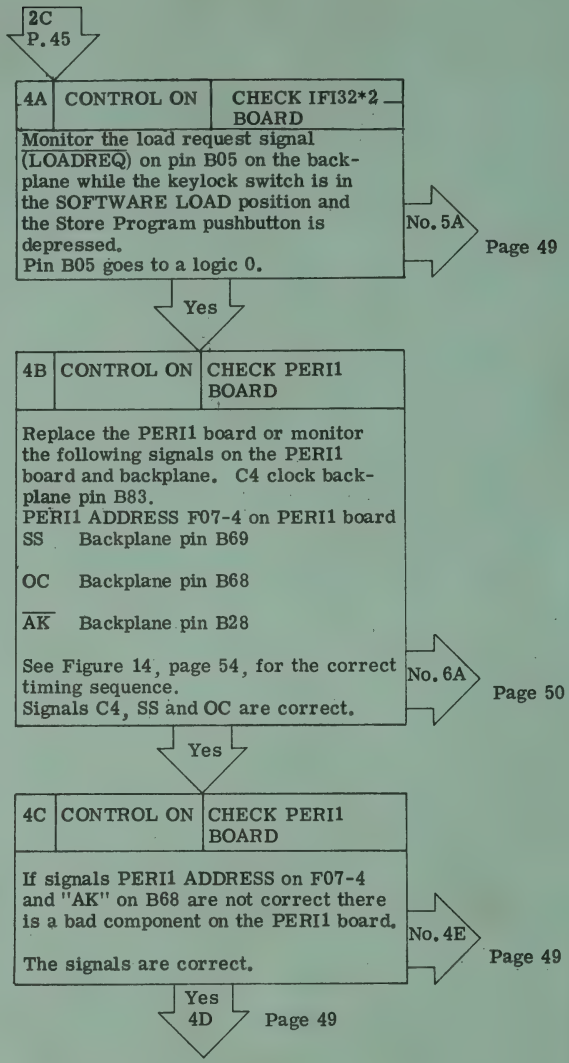
Page 48

Yes
2D

Page 48


2C
P. 45
2D
CONTROL ON
CHECK TAPE READER
The problem is in either the TRAD2 board or the tape reader.
Refer to GEK-25295 (1050T) or GEK-25281 (1054T) reference sheets 116, 117, 118 and to instructions for the reader, Chapter XI, while troubleshooting the reader circuits.
The problem has been corrected.
Yes
1A
Page 47


2B
P. 45
3A
CONTROL OFF
REPAIR CIRCUITS
Check for intermittent or bad switches, bad connections, bad connectors and open fuses. The problem has been corrected.
Yes
1A
Page 47


2C
P. 45
4A
CONTROL ON
CHECK IFI32*2 BOARD
Monitor the load request signal (LOADREQ) on pin B05 on the backplane while the keylock switch is in the SOFTWARE LOAD position and the Store Program pushbutton is depressed.
Pin B05 goes to a logic 0.
No. 5A
Page 49
Yes
4B
CONTROL ON
CHECK PERI1 BOARD
Replace the PERI1 board or monitor the following signals on the PERI1 board and backplane. C4 clock backplane pin B83.
PERI1 ADDRESS F07-4 on PERI1 board
SS Backplane pin B69
OC Backplane pin B68
AK Backplane pin B28
See Figure 14, page 54, for the correct timing sequence.
Signals C4, SS and OC are correct.
No. 6A
Page 50
Yes
4C
CONTROL ON
CHECK PERI1 BOARD
If signals PERI1 ADDRESS on F07-4 and "AK" on B68 are not correct there is a bad component on the PERI1 board.
The signals are correct.
No. 4E
Page 49
Yes
4D
Page 49

4C
P. 46

4D	CONTROL ON	MONITOR BACKPLANE SIGNALS

Data is being presented to the PERI1 board; however, the data may not be correct. Monitor the following signals on the backplane.
PERIPHERAL, Pin B78

OC, Pin 68

$\overline{AK}$, Pin B28

$\overline{SEO}$, Pin B41

$\overline{SE1}$, Pin B42

$\overline{SE2}$, Pin B43

$\overline{SE3}$, Pin B44

$\overline{SE4}$, Pin B45

$\overline{SE5}$, Pin B46

$\overline{SE6}$, Pin B47

$\overline{SE7}$, Pin B48

Refer to Figure 15, page 53 for the correct timing sequence.

The timing sequence is correct.

No. 6A
Page 50

Yes

4E	CONTROL OFF	REPLACE PERI1 BOARD

The previous test confirms that the PERI1 board is bad.

Replace or repair the PERI1 board.

Yes
1A
Page 47

4A
P. 46

5A	CONTROL OFF	CHECK IFI32*2 BOARD

Check jumper connection C01-A to C01-D on IFI32*2. Repair or replace the IF board.
Note: The diagnostics do not test the portion of the IF circuit required for loading system software tapes.

1A
Page 47

4B
P. 46

6A	CONTROL ON	CHECK CPU SIGNAL LEVELS

Any one of the following signals being at the incorrect logic level may prevent the CPU from operating. A signal being at an incorrect level may be due to a fault at either the signal source or one of the loads.

SIGNAL NAME	PIN	SIGNAL SRC.	LOGIC LEVEL
$\overline{\text{HDWCLR1}}$	B07	CPU	1
$\overline{\text{HALT}}$	B15	CPU	1
$\overline{\text{BUSY}}$	B16	RAM*	Frequency 93-1/3 KHz (11 μ sec.
MEMWNR	B17	CPU	0
$\overline{\text{MEMSTART}}$	B18	CPU	1
$\overline{\text{CPNL}}$	B20	CPSI1	1
$\overline{\text{MEMPARITY}}$	B21	RAM*	1
$\overline{\text{PRIORITYINPUT}}$	B22	IFI32*	1
$\overline{\text{ASR}}$	B23	CPSI1	1
$\overline{\text{TRDATA}}$	B24	PERI1	1
AXISCMPLT1	B25	AXIS2*	0
AXISCMPLT2	B26	AXIS2*	0
NOTE: 1050T has one AXIS2 board 1054T has two AXIS2 boards (check both).			
IFJAM	B80	CPSI1	0
POWERFAIL	L01	REG8	0

Correct signal levels are shown above.

No. 8A
Page 50

Yes

6B	CONTROL OFF	REPLACE CPU BOARD

Replace or repair the CPU board.

1A
Page 47

6A
P. 48

8A	CONTROL OFF	REMOVE NON-ESSENTIAL BOARD

Since the buses on the backplane are common to all boards, a fault on any board can affect the operation of other boards. To eliminate this possibility, remove all nonessential boards from the logic rack. The following is a list of boards required to load tape.

CPU

RAM* (Master Board)

PERI1

Recheck the signals listed in step 6A.

Signal levels are correct.

No. 9A
Page 52

Yes

8B	CONTROL OFF	CONNECT PIN B05 TO 0V

Place the diagnostic tape in the reader. Connect backplane pin B05 ($\overline{\text{LOAD REQ}}$) to 0 volts then push Control on. The tape should begin to run thus indicating that the problem is caused by one of the boards that has been removed.

Remove the jumper from pin B05.

The tape reader runs.

No. 4E
Page 49

Yes
8C
Page 52

1B
P. 47

7A	CONTROL ON	CHECK CONTROL STATION

If the Readout fails, the Cycle Start and Optional Stop lights on the Control panel simultaneously turn on and off, flashing. (In most systems, this test has been disabled by grounding RESPONSE.) The lights are not flashing.

No. 11A
Page 53

Yes

7B	CONTROL ON	CHECK TAPE POSITION

The position at which the tape stops provides a clue as to where the problem might be. If the reader stops after reading several inches of tape, this may indicate a tape or tape reader problem. Always check the tape for faults such as elongated sprocket holes and tears.

No. 10A

Reader reads several inches of tape.

Yes
7C
Page 51

7B
P. 49

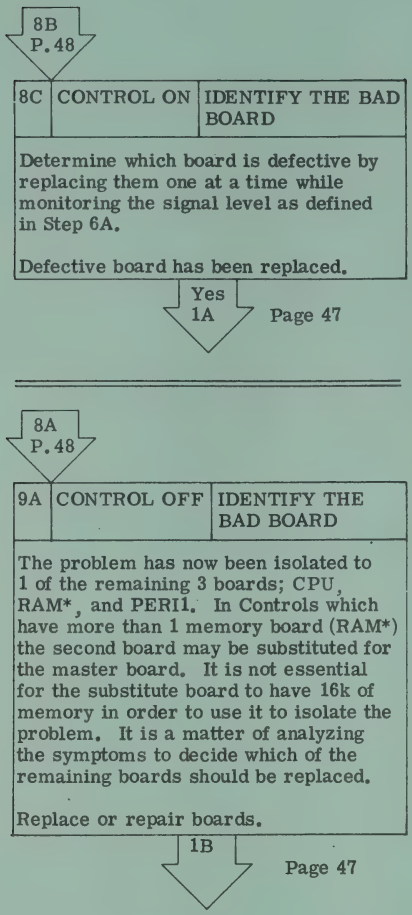
7C	CONTROL ON	CHECK TAPE READER

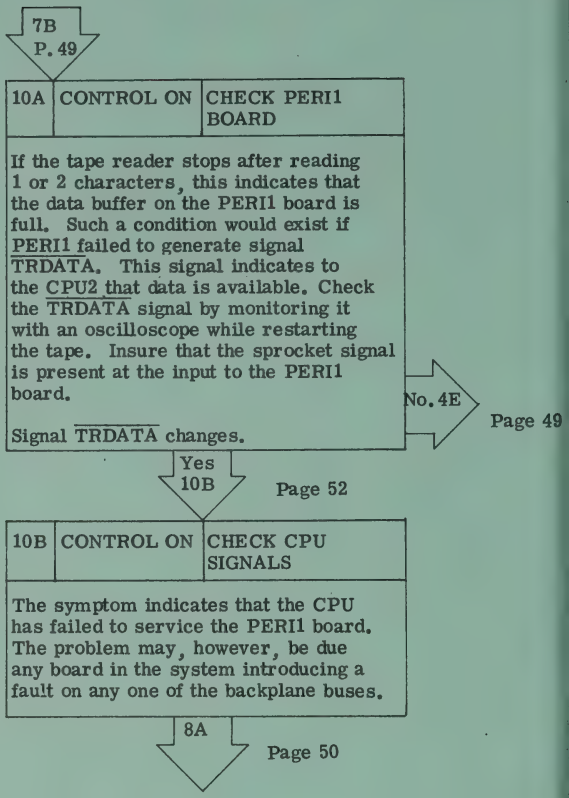
The tape reader circuits may be easily checked by using an oscilloscope to monitor the Track Signals at the input to the PERI1 board. Use a tape which has each track punched separately, 1 through 8 in sequence. Connect the FWD signal to OV (721TB-D located below tape reader) to make the reader run. Using an oscilloscope, monitor the Track and Sprocket signals on PERI1 UPL. The signals will transition between approximately OV and +12V. Refer to GEK-25295 (1050T) and GEK-25281 (1054T) reference sheets 116, 117, and 118 for tape reader wiring and to the tape reader instruction, Chapter XI, for the correct timing between Track and Sprocket signals.

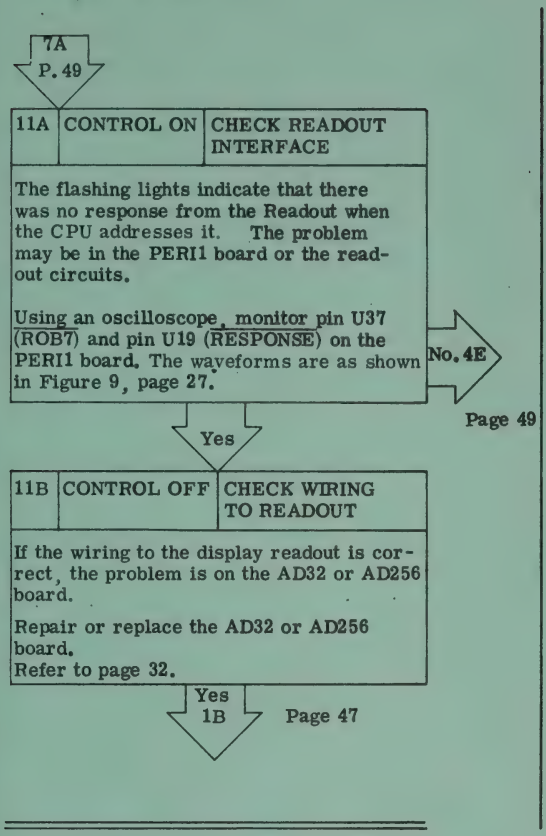
No. 4E
Page 49

Problem corrected in reader circuits.

Yes
1A
Page 47


8B
P. 48
8C
CONTROL ON
IDENTIFY THE BAD BOARD
Determine which board is defective by replacing them one at a time while monitoring the signal level as defined in Step 6A.
Defective board has been replaced.
Yes
1A
Page 47
8A
P. 48
9A
CONTROL OFF
IDENTIFY THE BAD BOARD
The problem has now been isolated to 1 of the remaining 3 boards; CPU, RAM*, and PERI1. In Controls which have more than 1 memory board (RAM*) the second board may be substituted for the master board. It is not essential for the substitute board to have 16k of memory in order to use it to isolate the problem. It is a matter of analyzing the symptoms to decide which of the remaining boards should be replaced.
Replace or repair boards.
1B
Page 47


7B
P. 49
10A
CONTROL ON
CHECK PERI1 BOARD
If the tape reader stops after reading 1 or 2 characters, this indicates that the data buffer on the PERI1 board is full. Such a condition would exist if PERI1 failed to generate signal TRDATA. This signal indicates to the CPU2 that data is available. Check the TRDATA signal by monitoring it with an oscilloscope while restarting the tape. Insure that the sprocket signal is present at the input to the PERI1 board.
Signal TRDATA changes.
No. 4E
Page 49
Yes
10B
Page 52
10B
CONTROL ON
CHECK CPU SIGNALS
The symptom indicates that the CPU has failed to service the PERI1 board. The problem may, however, be due any board in the system introducing a fault on any one of the backplane buses.
8A
Page 50


7A
P. 49
11A
CONTROL ON
CHECK READOUT INTERFACE
The flashing lights indicate that there was no response from the Readout when the CPU addresses it. The problem may be in the PERI1 board or the readout circuits.
Using an oscilloscope, monitor pin U37 (ROB7) and pin U19 (RESPONSE) on the PERI1 board. The waveforms are as shown in Figure 9, page 27.
No. 4E
Page 49
Yes
11B
CONTROL OFF
CHECK WIRING TO READOUT
If the wiring to the display readout is correct, the problem is on the AD32 or AD256 board.
Repair or replace the AD32 or AD256 board.
Refer to page 32.
Yes
1B
Page 47

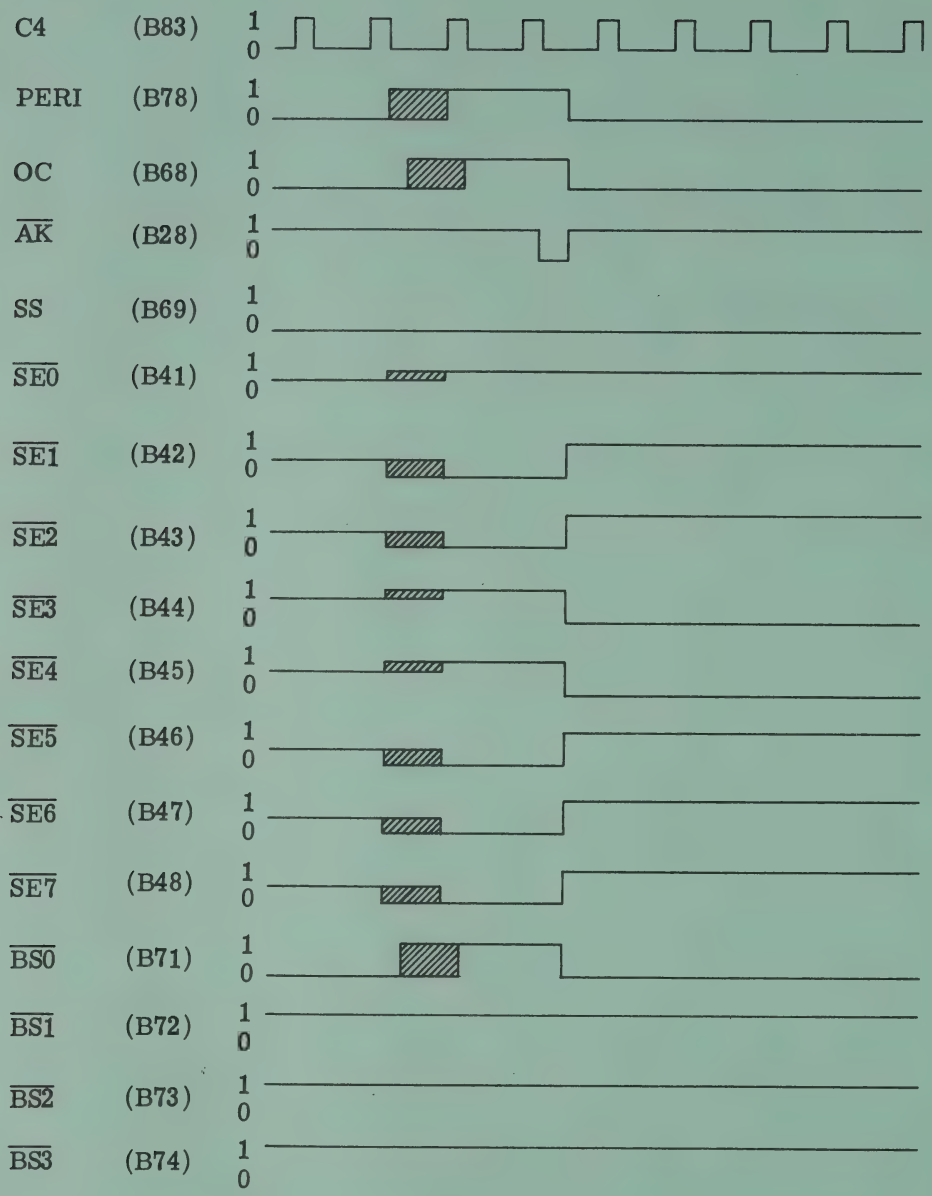


Figure 14.

NOTE: The timing sequence shown above will not be repetitive if an $\overline{AK}$ signal is not present, or the CPU fails to respond to the $\overline{AK}$ signal. Signals shown above on the ($\overline{SE}$) three-state buses will be a true logic level only when the PERI signal is at logic "1".

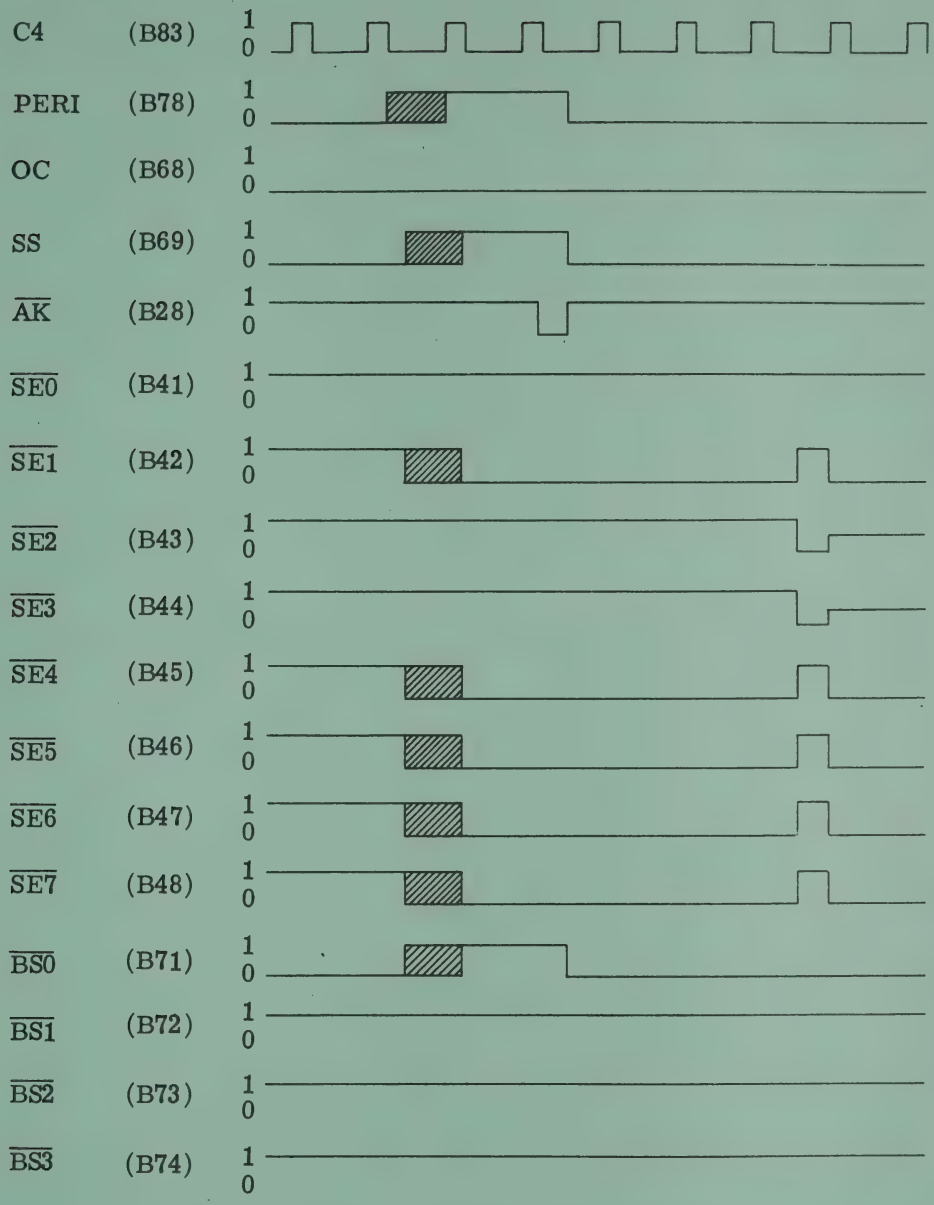


Figure 15.

NOTE: The status shown above (level of $\overline{SE}$ buses) indicates that the Tape Reader Run/Load Switch is in the LOAD Position. The pattern will be repetitive.

DIAGNOSTIC SOFTWARE FOR 1050T CONTROLS

April, 1978

Diagnostic Software is an additional troubleshooting aid. The information in this publication needs to be used in conjunction with the information contained in "Troubleshooting". The Diagnostics merely tell where the error is. Troubleshooting gives specific directions on what to do to correct the error.

Section 1 of this publication gives all of the information that the final user needs in order to be able to use these Diagnostics. It also gives background information needed by those doing in-depth testing.

Section 2 gives information for in-depth testing using the Diagnostics. In-depth testing requires the understanding of this section.

SECTION 1
INSTRUCTIONS FOR USING THE DIAGNOSTICS

Three diagnostic software programs are supplied with the Mark Century 1050T or 1054T Control: central processor test, memory test, and system diagnostic software. A description of these tests and directions for their use are given below.

The 3 diagnostic programs for the 1050T or 1054T Control are supplied on 1 physical tape. The central processor test is the first program on the tape. The memory test is second, and the system software is last.

By means of the tape reader, the programs may be loaded into memory, where they replace the executive software.

When testing is completed and the Control is again ready to run the machine tool, the executive software tape must be reloaded.

If a malfunction in the tape reader or related circuits prevents normal loading of tape programs, refer to "Troubleshooting", (GEK-36092).

If you run all the tests and the system still is not working, the problem may be intermittent and repeated tests may be required. Also, it may be necessary to use Mode 2 (operated-aided system tests described on page 12 and "Detailed Description of Boards," starting on page 14). In addition to checking boards, these tests check interconnection wiring and some machine wiring.

LOADING PROCEDURE

All tapes, both diagnostic and executive software, are loaded by following the same procedure.

Note: When loading any of the three programs the reader reads, hesitates, and then reads again. The hesitation is a memory clear program.

Place any part of the tape leader into the tape reader. If there is no Computer Access Panel, turn the Keylock switch to the SOFTWARE LOAD position. Depress and release the Control Off pushbutton. Depress the Store Program pushbutton and while it is held down, depress the Control On pushbutton and hold it down until the reader starts to read. Release the buttons.

If there is a Computer Access Panel, the procedure is: depress and release Control Off; depress and release Control On; then depress and release the Load Tape switch on the Computer Access Panel.

CENTRAL PROCESSOR UNIT TEST PROGRAM

The test for the central processor unit (CPU) verifies reliable performance of all central processor unit functions and can be executed without requiring a Computer Access Panel. Completion of the test is reported by a message on the display. Detected errors are reported on the display and on the typewriter, (baud rate-110; characters per second-10) if available. Initial loading of the tape, execution of the test, and output of messages require the successful operation of a number of central processor unit functions.

After the program is loaded, execution of the central processor unit test starts automatically. The Processor Error Light should be on. This indicates proper operation of the Watch dog timer. The execution time is about 10 seconds, not including time for error messages if there are any. When testing is complete, the message CPU TEST COMPLETE is shown for 4 seconds on the display and the test repeats. To terminate the central processor unit test, load the memory test, which follows the central processor unit test on the tape by following the loading procedure described above.

MEMORY TEST PROGRAM

The memory test reports any detected errors on the display and prints the same information on the typewriter if one is available. The time required to run the memory test depends on the amount of memory. The minimum time is a few minutes. The Processor Error light is normally on when running the memory test.

When testing is complete the message MEMORY TEST COMPLETE is shown for 4 seconds on the display and the test repeats.

The memory test program is loaded as described under "Loading Procedure".

Upon completion of loading, the program searches for the top of the memory, and displays the limits of memory to be tested in the following message:

MEM 29 XXX1 XXX2

29-Code for test limits message

XXX1-Lower limit of test

XXX2-Upper limit of test

If there is no typewriter, depress the Cycle Start pushbutton to start testing.

If there is a typewriter, the message is typed and testing starts automatically.

If the upper test limit in the message should disagree with the known size of system memory, a memory failure may have caused the top of memory search to fail.

Testing continues until another program is loaded. Refer to GEJ-5016 (located on inside of the back door of the Control) to determine the total memory. If the total memory is not the same as the limit message, replace the board that did not answer.

See the example below:

	MEMORY	
RAM NO.	AMOUNT	LOCATION
1	16K	0000-3FFF
2	8K	4000-5FFF
3	4K	6000-6FFF

The information on the label indicates 28K or 0000-6FFF.

If message is 29 0510 5FFF the upper limit of 5FFF indicates that Board 3 (RAM NO. 3) did not answer.

SYSTEM DIAGNOSTIC PROGRAM

To load the system diagnostic software, again repeat the loading procedure. When the diagnostic software is loaded, the tape is rewound automatically. If the Rewind option was selected, a rewind at the end of tape indicates that the tape is loaded correctly. Automatic rewind does not occur if the option was selected not to rewind when the tape was made as would be desirable for fan-fold tape. Next, the display shows PUSH CONTROL OFF, THEN CONTROL ON. Follow these instructions. However, if you are using the Computer Access Panel, also depress the Run switch.

Some system diagnostics have the ability to test a variable number of IFB32 and ODB32 boards. This is desirable whenever the number of IFB32 or ODB32 boards might be changed, as with the PCI option, for example. If the system diagnostic is able to select the number of IF/OD boards to be tested, the display will indicate the basic number of IF/OD boards by showing

PRESS NEXT FOR xIF, yOD BOARDS
or
PRESS OPTN STOP TO CHANGE

where x and y indicate the basic number of IF and OD boards, respectively. Press Next to indicate that the number of IF and OD boards is correct, or if the correct number is not known. Press Optional Stop if the number of IF and OD boards should be changed for this particular Control. If so, the display asks ENTER QTY OF IFI32 BOARDS. Respond by pressing the number of IFI32 boards on the digit keyboard on the control panel. The display then asks ENTER QTY OF ODI32 BOARDS. Respond by pressing the number of ODI32 boards on the digit keyboard.

The number of IFB32 and ODB32 boards in any Control may be determined by opening the rear door and observing the number of IFB32 and ODB32 boards present in the main logic rack.

At this time, the display may show one of the following messages:

NO ANSWER FROM IFI32*
NO ANSWER FROM ODI32*
PUSHBUTTON APPARENTLY DEPRESSED
REAL TIME CLOCK NOT OPERATING

For any of the above, refer to "Troubleshooting" (GEK-36092).

If the light in the Optional Stop pushbutton turns on, there is a malfunction which needs to be acknowledged. In general, this acknowledgment is done by depressing the Cycle Start pushbutton. In most cases, these messages are error messages.

An introductory message READY-ENTER DATA is then displayed. It is also typed on the typewriter, if a typewriter is being used.

The procedures for running the program from this point are described starting on page 3.

PROCEDURES TO RUN SYSTEM DIAGNOSTIC SOFTWARE

The three most commonly used procedures to run diagnostic software are described below: one test of all the boards, repeated tests of all of the boards, and repeated tests of only one board.

Names of pushbuttons are underlined, and messages which appear on the display are capitalized.

Special Messages are detailed on page 12.

TERMINATING TESTS

When tests are being performed with any of the following procedures, testing can be terminated by depressing Optional Stop, located on the Control Panel, until the light in the Cycle Start pushbutton goes out. When this is done, the display shows the last failure plus the total number of failures (see example on page 11). To acknowledge this message, depress Cycle Start. The display responds with READY ENTER DATA.

NOTE: If a TermiNet* printer is used, the Interrupt pushbutton on the panel TermiNet should be depressed rather than Optional Stop; and if a Teletype is used, the Break key on the Teletype should be depressed. When a TermiNet printer or Teletype is used, acknowledgement is not required and READY ENTER DATA automatically appears.

ONE TEST OF ALL BOARDS IN THE SYSTEM WITH NO OPERATOR-AIDED TESTS

No special test modes are required.

1. Put the Operation switch in the TEST position.

2. Load the tape as described on page 1.

3. When the display shows READY ENTER DATA, depress Cycle Start. All boards are tested and error messages appear on the display.

-IF-

the Operation switch was not in the TEST position, the display indicates

TURN OPERATION SW TO TEST MODE.

A. Turn the Operation switch to the TEST position.

B. Acknowledge the message by depressing Cycle Start.

C. The display indicates TOTAL ERRORS 00.

D. Acknowledge by depressing Cycle Start.

E. The display indicates READY ENTER DATA which allows the test to be restarted from step 3.

NOTE: If the test is being run from a typewriter (TermiNet printer or Teletype) perform steps 1, 2, and 3 above with the following exception. Depress the period (.) on the keyboard instead of Cycle Start. In this case, all messages are printed automatically with no acknowledgement required.

REPEATED TESTS OF ALL BOARDS (MODE 1)

Looping on any or all board tests requires special Test Mode 1.

1. Put the Operation switch in the TEST position.

2. Load the tape as described on page 1.

3. When the display indicates READY ENTER DATA, depress Next. The display responds with a period (.).

4. Enter "1" from the Control keyboard.

NOTE: If an error has been made prior to this step, depress Clear and start over again with step 3.

5. Depress Cycle Start. Boards are tested in the order listed in the Configuration List. The boards are tested repeatedly until Optional Stop is depressed which terminates the test.

NOTE: If the test is being run from a typewriter, perform steps 1-5 above with the following exceptions. Depress Carriage Return (CR) instead of Next and Period (.) instead of Cycle Start.

*Trademark of General Electric Co., USA

REPEATED TESTS OF ONLY ONE BOARD (MODE 1)

Looping on any or all board tests requires special Test Mode 1.

1. Put the Operation switch in the TEST position.

2. Load the tape as described on page 1.

3. When the display shows READY ENTER DATA, enter the slot number of the board whose test is to be repeated. The slot number is listed in the Configuration List shipped with your tape.

A sample configuration list is shown below.

4. Depress Next.

5. Enter "1" from the keyboard.

NOTE: If an error has been made prior to this point, depress Clear, and start over again with step 2.

6. Depress Cycle Start. Boards are tested in the order listed in the Configuration List until the specified board is reached. Then the board is tested repeatedly until Optional Stop is depressed which terminates the test.

NOTE: If a TermiNet printer or a Teletype is used, perform steps 1 and 2. Then, on the TermiNet printer depress the Interrupt key instead of Optional Stop. For the Teletype, depress the Break key. With either an acknowledgement is not necessary, and the display automatically shows READY ENTER DATA.

SAMPLE CONFIGURATION LIST

This is an example of a four-axis lathe (1054T). The two-axis system is similar but uses only one AXIS 2 and one THC1 board.

```
CONF: ;     BOARD BASE ADDRESS, SLOT,   BOARD TYPE   BOARD NUMBER
            .WORD 0000, 12,             PERI1        ; *1
            .WORD 0710, 20,             IFI32        ; *1
            .WORD 0610, 15,             ODI32        ; *1
            .WORD 0620, 14,             ODI32        ; *2
            .WORD 0720, 19,             IFI32        ; *2
            .WORD 0100, 03,             AXIS2        ; *1  First axis = x; second axis = z
            .WORD 0120, 02,             THC1         ; *1  Used with AXIS2 *1
            .WORD 0140, 05,             AXIS2          *2  First axis = u; second axis = w
            .WORD 0160, 04,             THC1         ; *2  Used with AXIS2 *2
            .WORD 0070, 08,             MAAU1        ; *1
```

NOTE:

The slot number listed is the assigned slot for each board. Even though these boards can be moved to other slots, the above assigned "slot number" must be used when specifying a board for diagnostic purposes.

SECTION 2
IN-DEPTH TESTING USING THE DIAGNOSTICS

Section 2 contains additional information on:

	Page
Central Processor Test Program	5
Memory Test Program	8
System Diagnostic Programs	9

It also describes:

Test Modes 1 through 4	12
Additional Features	
Memory Readout	12
Memory Write	13
Board Exerciser	13
Detailed Description of Board Tests	
IFI32	14
OD132	16
AXIS2	17
THC1	23
PERI1	27
MAAU1	29
PCI	32
CPSI1	35

CENTRAL PROCESSOR UNIT TEST PROGRAM

If there is no typewriter, the central processor unit test error messages appear on the display and remain there until acknowledged by depressing the Cycle Start pushbutton. Testing then continues. If there is a typewriter, the error message is typed and testing continues automatically.

The format of an error message for both display and typewriter is:

```
CPU XXX0 XXX1 XXX2 NN
```

XXX0 - contents of register 0
XXX1 - contents of register 1
XXX2 - contents of register 2
NN - number of failing test

The contents of registers are displayed in hexadecimal notation.

The Test/Error Code Listing is given on page 6. A description of the mnenonics precedes the listing.

MNEMONIC	DESCRIPTION	MNEMONIC	DESCRIPTION
HALT	Halt	PULL R	Pull from stack to register
PUSH	Push flags on stack	AISZ	Add immediate, skip if zero
RTI	Return from interrupt	LI	Load immediate
RTS	Return from subroutine	CAI	Complement, add immediate
PULL	Pull flags from stack	XCHRS	Exchange register, stack top
JSRI	Jump to sub implied	ROL	Rotate left
RIN	Register in	ROR	Rotate right
		SHL	Shift left
ROUT	Register out	SHR	Shift right
		AND	And
SFLG	Set flag	OR	Or
PFLG	Pulse flag	SKAZ	Skip if AND is zero
BOC	Branch-on condition	ISZ	Increment, skip if zero
JMP	Jump	DSZ	Decrement, skip if zero
JSR	Jump to subroutine	LD	Load
RADD	Register add	ST	Store
RXCH	Register exchange	ADD	Add
RCPY	Register copy	SUB	Subtract
RXOR	Register exclusive OR	SKG	Skip if greater
RAND	Register AND	SKNE	Skip if not equal
PUSH R	Push register to stack		

TEST/ERROR CODE LISTING

TEST	INSTRUCTION TESTED	REGISTER(S) USED
01	SKG	AC1
02	SKG	AC0
03	SKG	AC1
04	SKG	AC2
05	SKG	AC3
06	PUSH, PULL	STACK, AC1, AC2
07	PUSH, PULL	AC0, AC3
08	JSR	PC
09	JSR	STACK, AC2, AC3
0A	JSR, RTS	AC1
0B	LD, JSR	AC3 (INDEX)
0C	LD, JSR	AC2 (INDEX)
0D	LD, ST	AC0, AC1, AC3
0E	LD	AC2, AC3
0F	ST, LD	AC1, AC2
10	ISZ	AC0, AC1
11	DSZ	AC1, AC2
12	ISZ, DSZ	
13	RAND	AC0, AC1, AC2
14	RAND	
15	RXCH	AC2, AC0, AC1, AC3
16	RXCH	AC2, AC0, AC1, AC3
17	RXCH	AC2, AC0, AC1, AC3
18	RXCH	AC2, AC0, AC1, AC3
19	RXCH	AC2, AC0, AC1, AC3
1A	RXCH	AC2, AC0, AC1, AC3
1B	RXCH	AC2, AC0, AC1, AC3
1C	RXCH	AC2, AC0, AC1, AC3

(Continued)

TEST/ERROR CODE LISTING (Continued)

TEST	INSTRUCTION TESTED	REGISTER(S) USED
1D	SKNE	AC0
1E	SKNE	AC1
1F	SKNE	AC2
20	SKNE	AC3
21	SKAZ	AC0
22	SKAZ	AC1
23	SHR	AC1, AC2
24	SHR	AC0, AC3
25	SHR, SHL	AC0, AC1, AC2
26	ROL	AC2
27	ROR	AC3
28	ROL	AC0, AC1
29	ROL	AC0, AC1
2A	AND	AC0, AC1
2B	AND	AC0, AC1, AC2
2C	OR	AC0, AC1
2D	OR	AC0
2E	SHR, SHL, ROL, ROR	AC0, AC1, FLAGS (LIAKBIT)
2F	ROL	AC0, AC1, AC2 FLAGS (LIAKBIT)
30	SHR, SHL, ROL, ROR	AC0, AC1 FLAGS (LIAKBIT)
31	ROL, ROR	AC0, AC1 FLAGS (LIAKBIT)
32	ROR, ROL	AC0, AC1
33	PUSH, PULL	STACK, FLAGS, AC0, AC1
34	PUSH, PULL, ROL	STACK, FLAGS, AC0
35	BOC	RO
36	BOC	RO
37	BOC, ZEND	AC1, AC2, AC3
38	BOC, BIT, 0, 1	AC0, AC1
39	BOC, NP, NG, Z, N	AC0
3A	BOC	FLAG, (CARRY, SELX)
3B	BOC	FLAG, (CARRY, SELX)
3C	BOC	FLAG, (CARRY, SELX)
3D	BOC	FLAG, (OVERFLOW)
3E	BOC	FLAG, (OVERFLOW)
3F	BOC	FLAG, (OVERFLOW)
40	BOC	FLAG, (OVERFLOW)
41	ADD, SUB	AC0, AC1
42	ADD	FLAG, (CARRY, OVERFLOW) AC0
43	SUB	FLAG, (CARRY, OVERFLOW) AC0
44	ADD	FLAG, (CARRY, OVERFLOW) AC3
45	SUB	FLAG, (CARRY, OVERFLOW) AC3
46	ADD	FLAG, (CARRY, OVERFLOW) AC2
47	SUB	FLAG, (CARRY, OVERFLOW) AC2

(Continued)

TEST/ERROR CODE LISTING (Continued)

TEST	INSTRUCTION TESTED	REGISTER(S) USED
48	BOC (STKFUL), PULL	AC2, STACK
49	BOC (STKFUL), PUSH	AC0, AC1, AC2, STACK
4A	BOC (STKFUL), PUSH	AC0, AC1, AC2, AC3, STACK
4B	PUSH, PULL	AC0, AC1, AC2, AC3, STACK
4C	PUSH, PULL	AC0, AC1, AC2, AC3, STACK
4D	LD@	AC3
4E	LD (PC RELATIVE)	AC1, AC2
4F	LD @	AC1, AC2
50	ST @	AC3
51	ST @	AC1, AC2
52	ST @, ST	AC2 (INDEX)
53	JMP, JMP @	(PC RELATIVE)
54	JMP @	AC2 (INDEX) AC0
55	JSR @	AC2 (INDEX) AC0
56	SFLG	FLAGS
57	SFLG	FLAGS, STACK
58	PFLG	(RIAL TIME CLOCK INTERRUPT)
59	SFLG, PFLG	(MEMORY, PARITY, INTERRUPT)
5A	SFLG, PFLG	(FALSE ACKNOWLEDGE INTERRUPT)
5B	SFLG, PFLG	FALSE ACKNOWLEDGE INTERRUPT)

MEMORY TEST PROGRAM

The memory test program automatically runs an address test, word test, and bit test on the entire memory except for the area occupied by the program, repeating all tests until it is stopped. The testing is thorough, involving 91 stores and verifications at each memory location. The running time is about 5 minutes and 30 seconds for a 16K memory, not including time for error messages. To test the entire memory at least once, allow the program sufficient time. For a visible indication, watch the Cycle Start pushbutton. When the light in the pushbutton flashes on for the third time, the test has been completed, and it is starting to repeat. During the test of a 16K memory, the Cycle Start pushbutton is lighted for about 4 seconds, followed by a dark period of about 2 minutes and 40 seconds. Two such light and dark cycles complete the test. The times described vary in proportion to the size of the memory being tested.

If there is no typewriter, memory test error messages appear on the display and remain there until acknowledged by the operator who must depress the Cycle Start pushbutton. Testing then continues.

Memory errors are reported on the display in the following formats:

1. Memory parity error or no memory response (false acknowledge).

MEM ZZ XXX1 XXX2

ZZ Error code:

07-Memory parity error

28-False acknowledge

XXX1-Address of test location*

XXX2-Program counter when error was recognized.

2. Parity error generation and detection test.

MEM 48

48 Error code:
Parity error initially present cannot be cleared by o.

*To determine which memory board contains this memory address, refer to the board assignment label on the Control (GEJ-5016) located on the inside of the back door.

MEM ZZ XXX1 XXX2 XXX3 XXX4

ZZ Error Code:

42-Failure to generate and detect intentional parity error

44-OC failed to clear intentional parity error

46-Normal parity generation not restored by memory write

XXX1-Address of test location

XXX2-Correct word stored

XXX3-Word read from memory

XXX4-Incorrect bits

3. Address test error

MEM 20 XXX1 XXX2

20-Code for addressing error

XXX1-Address of test location

XXX2-Word read from memory

4. Word test or bit test error

MEM YY XXX1 XXX2 XXX3 XXX4 XXX5

YY Error code:

15-Word test, regular test

13-Word test, complement test

11-Word test, recomplement test

25-Bit test, regular test

23-Bit test, complement test

21-Bit test, recomplement test

XXX1-Address of test location

XXX2-Correct pattern

XXX3-Word read from memory

XXX4-Incorrect bits

XXX5-Bits under test (Mask used for complementing bit pattern)

If there is no typewriter, the Optional Stop light in the pushbutton is lighted and testing stops when an error is reported. Depress the Cycle Start pushbutton to acknowledge the error and resume testing.

If there is a typewriter, the error report is typed in one of the formats described above, and testing resumes.

To terminate memory testing, load the system diagnostic program, which follows the memory test on the tape, by following the loading procedures on page 1.

SYSTEM DIAGNOSTIC PROGRAM

The system diagnostic software consists of 3 sections as shown in Figure 1.

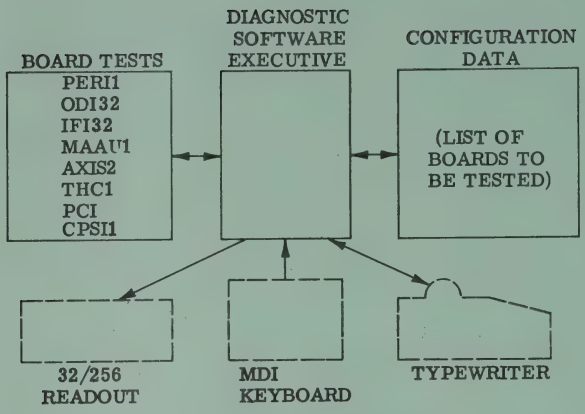
The Diagnostic Executive software communicates with the user and tests the individual boards.

The configuration data, which is tailored to each Control, determines the order of testing the boards and contains, for each board, the corresponding slot number for use in error reports. The listing of the configuration data is supplied as a 44S286--- drawing number for each Control. See page 4.

If, for any reasons, a printed-circuit board is physically moved to a slot other than the assigned slot, the diagnostic software continues to use the assigned slot number in error reports until the configuration data is changed to agree with the physical location of the board.

If the system diagnostic is able to test a variable number of IFI32 and ODI32 boards, the configuration list will contain the maximum number of IFI32 and ODI32 boards. The system diagnostic software tests only those boards which the operator indicates are present. See the procedure detailed on page 2.

As described later, the system software program is directed to conduct a sequence of testing. At the conclusion of the tests, the READY-ENTER DATA message is again displayed and the Control waits for further directions before proceeding.



Note: If the Processor Error light is on, turn the Control off and back on to clear it before starting the test. If this isn't done, an ODI32 error code 10 for board #1 will be indicated.

Figure 1.
BLOCK DIAGRAM
1050 SYSTEM DIAGNOSTIC PROGRAM

MESSAGES

After the system diagnostic has been initiated, the following 2-line message is typed.

DIAGNOSTIC REPORT 44S286XXX-YYY

READY-ENTER DATA

The same 2 lines are typed when the Control is turned on with the diagnostic software already loaded. "XXX" denotes the last 3 digits, and "YYY" the revision number of the diagnostic software identification number.

If there is no typewriter, the first line of the above message is not displayed. However, the second line is presented on the display whether or not a typewriter is present.

There are 4 other types of messages which the system can supply to the operator: response, run-time, summary or footer, and special messages. All but the first have identical form in both typewriter and MDI Keyboard modes of operation. These are displayed for operator acknowledgment in the MDI Keyboard mode of operation and are typed (and displayed briefly) in the Typewriter mode. (The "mode" of operation is established by the user when he responds to the READY-ENTER DATA message by the use of either the MDI keyboard or the typewriter.)

The four types of messages are described below.

Response Messages

Response messages during operator input of options.

Run-Time Messages

Run-time messages are suppressed by NO DISPLAY (Mode 3). Error messages have one of the following formats:

A. 15 ODI32 10

B. 15 ODI32 20 HEX 00 00 C0 00

C. 02 THC1 50 03 AXIS2

Message A

Message A states that error code 10 applies to the ODI32 board in slot 15. Refer to the error descriptions for the ODI32 board (page 16) for the meaning of error code 10.

Message B (SIMILAR TO A)

The difference between message B and A is that 4 pairs of hex characters have been added to B. Refer to the error description for the ODI32 under code 20 for the meaning of the hex characters, each of which represents 4 bits of auxiliary binary data. Other board types may use more or fewer than the 8 hex characters shown for the ODI32 board.

Message C

Message C states that error code 50 applies to the threadcutting board in slot 2. In addition, the AXIS* board in slot 3 could be contributing to the fault since the 50 series tests are interconnect tests.

Summary or Footer Message

At the end of a test sequence, a message is supplied in the following format:

15 ODI32 20 TOTAL ERRORS 03 M

This says that the last run-time message referred to the ODI32 board in slot 15, with error code 20. During the test sequence, the total number of errors was 3.

The presence of the "M" indicates that errors were found on more than one board. If more than 99 errors were detected during repeated testing, TOTAL ERRORS 99 + appears.

Special Messages

Various conditions in the Control can produce one or more of the following special messages, which call for obvious action, or else indicate the need of hardware repair. To restart the program, depress the Control Off, then the Control On pushbuttons.

A. PRESS NEXT FOR xIF, yOD BOARDS, OR PRESS OPTN STOP TO CHANGE.

   These messages ask the operator to indicate if the quantity of IFI32 and ODI32 boards to be tested is correct.

B. ENTER QTY OF IFI32 BOARDS.

C. ENTER QTY OF ODI32 BOARDS.

   These messages are used to modify the quantity of IFI32 and ODI32 boards to be tested.

D. NO ANSWER FROM PERI1 (Readout) (typed)*

E. REAL TIME CLOCK NOT OPERATING.

F. NO ANSWER FROM IFI32*__.

G. NO ANSWER FROM ODI32*__.

H. PUSHBUTTON APPARENTLY DEPRESSED.

   (8 sec has expired and a pushbutton on the operator's panel is apparently still depressed)

I. TURN OPERATION SW TO TEST MODE.

J. TYPEWRITER INPUT XMISSTION ERROR.

   This message is followed by 2 hex characters giving the offending status byte sensed during keyboard input.

K. COMPUTER MEMORY PARITY ERROR.

   This message is followed by 4 hex characters giving the value in the program counter when the parity error was recognized.

NOTE: The 1054T has two AXIS 2 boards either of which could be contributing to the fault.

*If PERI1 does not answer and there is no typewriter, the Cycle Start and Optional Stop panel lights blink on and off.

If system diagnostic testing is required other than one test of all boards, the special test modes must be used. The 4 special modes of operation are described below. When operating from the Control, mode entry is always preceded by depressing Next.

When operating from a typewriter, a comparison of the equivalent entries is given below.

	Control Panel	TermiNet	Teletype
Slot, Mode	Keyboard number	Keyboard number	Keyboard number
Slot Termination	Next pushbutton	CR (Carriage Return)	CR (Carriage Return)
Test initiate	Cycle Start	Period (.)	Period (.)
Terminate Test	Optional Stop pushbutton	Interrupt pushbutton	Break key
Correct Mistakes	Clear	Delete	Rubout

Any combination and order of modes (1, 2, 3, and 4) can be specified. The data (the last 4 characters of mode entered) is shown on the display when operating from the operator's control panel.

Modes do not have to be entered in any particular order. Multiple entries of a particular entry are ignored.

Example of readout
1222

which signifies that modes 1 and 2 are specified and will be active when Cycle Start is depressed.

NO MODES ACTIVE - ONE TEST OF ALL BOARDS

When no special test modes are specified before Cycle Start is depressed, one test is made on each board. To cease testing after a particular board, enter the slot number only.

MODE 1 - LOOP ON BOARD TEST(S)

Mode 1 is used for looping on the test of 1 board or all boards. The board slot number is entered to specify looping on a particular board. Enter the slot number, depress Next and then 1.

MODE 2 - OPERATOR-AIDED TESTS

Mode 2 (operator-aided tests) includes readout exercise, handcrank routines on AXIS2* and THC1*1, and MFO and Reversal Error switch test on THC1*1. For further information, see "Detailed Description of Board Tests" starting on page 15.

MODE 3 - NO DISPLAY OF ERROR MESSAGES

Mode 3 suppresses error messages to allow continuous testing and keeps track of the number of errors as described on page 11 (Summary of Footer Messages).

NOTE: The 1050T has one each of AXIS and THC1 boards. The 1054T has two each of these boards.

MODE 4 - LOOP ON TEST WHEN ERROR IS DETECTED

Boards which have the capability built in (presently AXIS2*, MAAU1, THC1*, and PCI1/2) respond to Mode 4. When Mode 4 is active and an error is encountered, the test goes into a small loop on the failed test. Without this capability, a particular board test is discontinued when the first error is encountered. Using this mode, the rest of the board can still be tested by exiting the loop as follows:

1. Depress Cycle Start (9 - 10 sec.) which allows the Control to continue and to stay in Mode 4.

-OR-

2. Depress Optional Stop which allows the Control to continue testing but without Mode 4.

Mode 4 can be entered using the typewriter, but Cycle Start and Optional Stop still must be used as described above.

It may be desirable to go in and out of Mode 4 when testing. If a Computer Access Panel is connected to the Control, this can be done through the panel. The Mode 4 flag is located at "00F0". A non-zero value indicates that the mode is active.

For most of the AXIS2*, MAAU1, THC1*, and PCI tests, the test remains in the loop, even if the error disappears. While in the loop the number of errors is recorded in a counter located at "00F1 and 00F2".

ADDITIONAL FEATURES

These features were designed primarily for GE factory test and require extensive system knowledge before use.

MEMORY READOUT

Stored memory data can be shown on the display as follows:

1. Start with READY ENTER DATA.
2. Enter "99" from the keyboard.
3. Depress Next. The display shows MEMREAD.
4. Enter the memory location through the keyboard. For A through F, enter first + and then 1 through 6 as shown in the table below.

A THROUGH F ENTRY

DESIRED CHARACTER	ENTRY
A	"+" Then 1
B	"+" Then 2
C	"+" Then 3
D	"+" Then 4
E	"+" Then 5
F	"+" Then 6

5. When the desired location is entered, depress Next. The display indicates the desired location and the succeeding three locations.

6. Depress Next again to get the next 4 locations.

7. Depress (-) which allows the new address to be entered.

8. Depress Optional Stop and the READY ENTER DATA message is displayed.

MEMORY WRITE

To use this feature, proceed as follows:

1. Start with READY ENTER DATA.

2. Enter "88" from the keyboard.

3. Depress Next. The Readout displays MEM-WRITE.

4. Enter the location to be changed through the keyboard. (1 - 6, the same as Memory Read above.)

5. Depress Next pushbutton. The display shows the address plus the stored data.

6. Enter the desired new data. It will be displayed as shown below:

	XXXX	XXXX	XXXX
		Stored	New
MEMWRITE	Address	Data	Data

7. When you are satisfied with the new data, depress Next again. New data is stored and the readout is updated.

8. Depressing (-) allows new data to be entered.

9. Depressing the Optional Stop pushbutton returns the Control to READY ENTER DATA.

BOARD EXERCISER

This routine allows exercising any board in the system directly from the Control keyboard. Results appear on the display and on the typewriter (if one is connected). For this routine to be entered, storage location 'OOEF" must be non-zero.

Detailed examples are given in "Troubleshooting". Communications with the board are accomplished with the following instructions:

1. OC - Output Command
2. SS - Sense Status
3. WW - Write Word
4. RW - Read Word

To use this routine, proceed as follows:

1. Start with READY ENTER DATA.

2. Enter 77 from the keyboard.

3. Depress Next. The display then shows:

OPOC BWC0000 DTA0000 *ADRXXXX

4. The first entry which can be made is the board address (as shown on the Configuration List, page 4). The displayed address is the last address programmed. Change it if desired. Then depress Next.

5. The * will move to *OPXX.

The operation can now be set as follows:

1 = Output Command
2 = Sense Status
3 = Write Word
4 = Read Word

When satisfied, depress Next.

6. The * moves to *BWC0000. The Byte Word counter necessary for the desired board action can now be entered. The actual byte word counter portion (most significant 6 bits) can be incremented by depressing INCR+. When satisfied, depress Next.

7. The * moves to *DTA0000. Enter data IF required.

8. Continue to use Next to rotate * for any additional changes.

9. Depress Cycle Start to activate the command.

10. The display and typewriter will indicate:

A. The command data for output command and write word.

B. The command information and retrieved data for sense status and read word.

11. The program returns to *BWCXXXX to allow changing or incrementing the byte word counter.

12. Depressing Next allows again rotating * as required for the next operation.

13. Depressing Optional Stop returns the Control to READY ENTER DATA.

14. A non-zero value in location OOEE inhibits typewriter operation for this function.

INPUT/OUTPUT (I/O) DEVICE CHECK

This routine allows checkout of input and output devices used in the Diagnostics.

To use the routine, proceed as follows:

1. Start with READY ENTER DATA.

2. Enter 44 from the keyboard.

3. Depress Next. The display then shows:

   INPUT DEVICES, DEPRESS NEXT.

4. Depress Next and the display indicates the first input device CYCLE START.

5. If Cycle Start is okay, the display will indicate the next device when Cycle Start is depressed. If Cycle Start is not okay, repair-or-skip to the next device by depressing Next.

NOTE: Since the routine requires the input to first not be active and then be active, when TEST is displayed, the switch must be switched off the TEST position and then back to the TEST position.

6. At the completion of input devices the display shows:

   OUTPUT DEVICES, DEPRESS NEXT

7. Depress Next. The display shows:

   CYCLE START

and the Cycle Start light is lit.

8. Depress Next. The display shows:

   OPTIONAL STOP

and the Optional Stop light is lit.

9. Depress Next and the routine returns to

   READY ENTER DATA

Special assemblies for GE Manufacturing QC include all inputs and outputs in this routine to allow device checkout without executive assistance.

DETAILED DESCRIPTION OF BOARD TESTS

A detailed description of the test for each board is given below.

Table 1 below shows a comparison of the quantity of the following boards in the 1050T standard Control and the 1054T standard Control.

Board Type	Quantity Located In 1050T Control	Quantity Located In 1054T Control	Comments
IF132	2	3	
OD132	2	3	
AXIS2	1	2	The AXIS2 and TCH1 boards in the 1054 Control are independently cross-tied for each set of axes.
THC1	1	2	

IFI32*

The test on the IFI32* board takes approximately 50 ms for each IF132 board.

All output commands and read data use subroutines which check for false acknowledge.

Before each check for error, the board is put into a not-test condition to avoid inhibiting normal use of the panel buttons with the diagnostic program in the MDI keyboard mode.

Procedure

1. Reads and stores initial contact states.

2. Commands the Test mode with the contacts open. After 1 ms, reads and checks that all states = 0. Commands not-test; wait 4 ms, and reads contact states; stores as DATA1.

3. Waits 8 ms and reads contacts states; stores as DATA2.

4. Checks that DATA1 = all 0's (time constant 4 ms).

5. Checks that DATA2 = initial states (time constand 12 ms).

6. Repeats the steps, except in the opposite sense. Step 2 commands and checks that contacts are closed and step 4 checks that DATA1 = all 1's.

7. Tests interrupts.

A. Creates an interrupt by first commanding that the contacts close, then clears any interrupt by read data; and finally commands open and enable, and checks that the interrupt occurs.

B. Creates an interrupt; then clears the interrupt rupt by reading data, and checks that it actually cleared.

C. Repeats 7A, except that the command to open contacts also disables the interrupt. Checks that the interrupt does not occur.

D. Repeats 7A except in the opposite sense; commands contacts open, clears interrupt, then commands closed and checks that the interrutp occurs.

Error Indications

Any false acknowledge or successful passing of all tests causes testing to be concluded. Other errors are reported and testing resumes. At the conclusion of testing, the board is commanded to the not-test, not-enable Interrupt mode.

CODE	ERROR CODE DESCRIPTION
2	False acknowledge on the output command.
5	False acknowledge on the read data command.
31	Cannot force all inputs open.
32	Time constant too short during transition of contacts from open to closed.
33	Time constant too long during transition of contacts from open to closed.
34	Cannot force all inputs closed.
35	Time constant too short during transition of contacts from closed to open.
36	Time constant too long during transition of contacts from closed to open.
37	Failed to generate interrupt on contact opening.
38	Interrupt not cleared by read data.
39	Not enable command failed to prevent interrupt.
40	Failed to generate interrupt on contact closure.

Auxiliary Information

Messages with codes 31-36 provide 4 bytes of auxiliary information to identify the faulty filter channels.

The 4 bytes are displayed as 8 hex characters which are related to the 32 filters according to the following table:

Hex Char. No.	1	2	3	4	5	6	7	8
Filter No.	32-29	28-25	24-21	20-17	16-13	12-9	8-5	4-1

The 1's in decoded hex characters identify faulty filters. For example: An error on filters 6, 18, 19, 25, 30 and 32 produces the following hex characters:

Hex Char.	A	1	0	6	0	0	2	0
Decoded	1010	0001	0000	0110	0000	0000	0010	0000

OD132*

The program which tests the OD132* board runs approximately 60 ms for each board and does the following:

1. Commands all 32 elements off.

2. Senses the edge jumper and initializes to start the test with element #1 if there is no edge jumper or with element #3 if there is an edge jumper.

3. Tests elements in sequence: 1, 2, 3, 4, etc.

4. Commands the element on, and repetitively senses until it turns on; then, commands all elements off. If the element does not come on within 50 ms, it is declared faulty. A corresponding bit is set in an error record, all elements are commanded off, and the next element is tested.

5. Any false acknowledge terminates the test.

6. The failure of all elements to go off in step 1 terminates the test.

7. The failure of 1 or more elements to turn on produces message code 20, and 4 bytes of auxiliary data, which identify the faulty elements by "1's".

8. In the unlikely event that an element which successfully turned off in step 1 fails to turn off in step 4 after having turned on in step 4, testing is terminated, message code = (element number) +20 and auxiliary data bytes are output, which may or may not contain "1" relating to elements tested earlier.

Error Codes

CODE	ERROR CODE DESCRIPTION
1	False acknowledge.
10	One or more elements could not be turned off at the start of the test.
20	The test was completed; 1 or more elements failed to turn on. Auxiliary information identifies the fault (s).
21, 22 through 52	Element 1, 2 through 32 could not be turned off. Higher-numbered elements were not tested. Auxiliary information shows if any tested elements failed to turn on.

Auxiliary information

Messages with codes 20-52 provide 4 bytes of auxiliary information to identify faulty elements. The 1 bytes are displayed as 8 hex characters, which are related to the 32 elements according to the following table:

Hex Char. No.	1	2	3	4	5	6	7	8
Element No.	32-29	28-25	24-21	20-17	16-13	12-9	8-5	4-1

1's in decoded hex characters identify faulty elements.

For example: An error on elements 6, 18, 19, 25, 30 and 32 would produce the following hex characters:

Hex Char	A	1	0	6	0	0	2	0
Decoded	1010	0001	0000	0110	0000	0000	0010	0000

AXIS2*

The AXIS2* test requires 6 to 8 seconds to run per board. This diagnostic has the "Loop On Test When Error Is Detected" capability (Mode 4).

If Mode 4 is active and an error is detected:

1. The display indicates the slot number of the board that caused the error code.

2. The operator must depress Cycle Start 6 to 8 seconds to acknowledge the message.

3. If there is hex auxiliary data, it is also displayed and must be acknowledged by again depressing Cycle Start 6 to 8 seconds. The test is now in the loop.

4. To exit the loop and leave Mode 4, depress Optional Stop.

The AXIS2* board is tested in the following sequence.

First the bus handshaking circuitry is exercised to ascertain that no false acknowledge occurs when doing any of the following with the No. 1 and No. 2 axes:

OC Output Command
SS Sense Status
WB Write Byte
RB Read Byte

A complete stack test is accomplished including pattern checks address checks, and interference checks.

When a failure occurs on a stack test, the auxiliary display shows:

XX	XX	XX
Stack Address	Correct Data	Actual Data

Address

Address	Stack
00-0F	A3
10-1F	A1
20-2F	B1
30-3F	B3
40-4F	A2
50-5F	B2

Four additions and 4 subtractions check the arithmetic unit. The auxiliary information for the arithmetic unit is:

XX	XX	XX	XX
A Input Data	B Input Data	Correct Data	Actual Data

The balance of the tests occur in the order shown below:

20-22 Tests

Test 20 checks the excitation counter and sine and cosine generation. The auxiliary information is the reference counter count (hex) at the time the failure occurred.

Tests 21 and 22 preload the error counters and allow them to time out. They then check that the time approximately 100 microseconds for LSD (Least significant digit) and 400 microseconds for MSD (most significant digit) is correct. "00" is written to the board and it is complemented to 255 for LSD and 127 for MSD. Test 21 checks the first axis and Test 22 checks the second axis.

The Auxiliary information format is:

XX	XX
Most Significant Digit Code	Least Significant Code

Code

00 - No error
01 - Not clear to start
02 - Count out too fast
03 - Count out too slow

30 - 39 Series Tests

The 30-39 tests generate artificial waveshaper interrupts to check delta position extended (equivalent of absolute position) previous position, and the discriminator calculations.

NOTE: The 1050T has 1 AXIS2 board with 1 set of axes. The 1054 has 2 AXIS2 boards. Each have 1 set of axes each of which is tested independently.

Even numbers test the first axis and odd numbers test the second axis. When an error occurs, the auxiliary information is:

DATA			
XX XX	FF FF OX XX	XX XX	XX XX
Correct Data	Delta Position Extended - (Actual Data)	Previous Position (Actual Data)	Discriminator (Actual Data)

When an error is detected in the 30 Series test and Mode 4 is active, the test loop stops at the point of failure. When Cycle Start is depressed to exit the loop, the next test will be Test 40.

Example:

Failure on Test 33 Loop Test = 30 through 33
When Loop, Skips Tests 34-39 and goes to Test 40

40-51 Tests

Tests 40 and 41 check lead screw compensation for the first and second axis.

Auxiliary information containing correct and actual discriminator for + and - is:

01F4	XXXX	00F5	XXXX
Correct + Data	Actual + Data	Correct - Data	Actual - Data

Tests 42-51 check axis flags for distance zero, out-of-position, error limit, and out-of sync.

Auxiliary information is:

XX
Auxiliary
Code

Auxiliary Code

01 - The flag did not clear with diagnostic clear.

02 - The flag had the wrong sense when 0 was loaded and compared to discriminator of 250.

03 - The flag had the wrong sense when 255 was loaded and compared to discriminator of 250.

52-58 Tests

Test 52 checks loss of feedback detection circuitry. Loss of feedback sets anytime the reference counter is not running.

The auxiliary information is:

XX
Auxiliary
Code

Auxiliary Code

01 - Not set when reference counter is not running.
02 - Not clear when reference counter is running.

Tests 53-58 check axis complete circuitry.

Tests 53 and 54 check basic Axis Complete 1 and Axis Complete 2 circuitry. The auxiliary information is:

XX
Auxiliary
Code

Auxiliary Code

01 - AC1 error
02 - AC2 error
03 - AC1 and AC2 error

Tests 55-58 are all tested through Axis Complete 1. These tests check axis complete for distance zero and in position.

60-69 Tests

The sixty series tests check linear path computation for different scales and signs.

For tests 60-67 the auxiliary information is:

XXXXXXXX
Distance at
End of Test

For tests 60-65, distance should be 0. For tests 66 and 67, distance should be - 1 (FFFFFFFF).

Tests 68 (first axis) and 69 (second axis) are timed path computation tests. Auxiliary information is:

01 X X X X X X X X	02 X X X X X X X X
Distance for First Half of Test Should Not Be 0.	Distance for Second Half of Test Should Be 0.

70-72 Tests

The seventy series test circular interpolation. (Requires THC1* board.)

NOTE: The 1050T has 1 THC1 board; the 1054T has 2.

The two axes of the AXIS2* board are cross-tied and both counting down. The distance is 1.5 times the function-generator. Final function-generator values for both axes are read and checked for error. For the 1054T, AXIS2 boards are independently cross-tied for each set of axes.

The auxiliary information is:

01 X X X X X X X X	02 X X X X X X X X
First Axis Final Function-Generator Value	Second Axis Final Function-Generator Value

The final function-generator value for both axes should be 000003F8.

76-77 Tests

Tests 76 and 77 use the memory stack on the AXIS2 board to check the Block I/O capability of the CPU. Test 76 checks the Block-Read function; test 77 checks the Block-Write function.

The auxiliary information for both tests is:

XX	XX	XX
Stack Address	Correct Data	Actual Data

80-81 Tests

NOTE: The 1050T has 1 AXIS2 board and handcranking is done only on 2 axes. The 1054T has 2 AXIS2 boards and handcranking is done on 4 axes. The x and z axes are handcranked during AXIS2*1 testing and the u and w axes are handcranked during AXIS2*2 testing.

Test 80 is a Mode 2 (operator-aided) test. When Mode 2 is active, handcranking either motion causes the appropriate axis calculations to take place and reads out actual absolute position (delta position extended) and discriminator.

They track the resolvers when the motion is handcranked. Positive motion causes count down; negative motion causes count up for actual absolute position. The discriminator counts up for positive motion and down for negative motion. Change should be smooth as the motion is handcranked. Jumps can be caused by resolver single phasing.

The display shows:

1 XXXXXXXX XXXX		2 XXXXXXXX XXXX	
First Axis Absolute Position	First Axis Discriminator	Second Axis Absolute Posn.	Second Axis Discriminator

Exit Test 80 by depressing Cycle Start.

Test 81 is an analog exerciser used primarily by General Electric Company manufacturing to test boards. The test can only be entered when Mode 2 is active and the flag at 00F3 is set. Emergency stop circuitry must be overridden to actually move the motions. This routine is terminated by depressing Optional Stop.

When test 81 is entered the display shows:

'AXIS2* TEST 81 DEPRESS NEXT'

continue as follows:

1. Depress Next, the display shows

ANALOG-AXIS 1 DIR ± IPM 00 L 0000.

This indicates 1st axis, plus (+) direction, 0 IPM and no. lag.

2. Jumper ESTOPIND to GND (pin B10 on AXIS 2 board). Note that this overrides emergency protection and should only be done on the simulator.

3. Set up the desired motion using the keyboard. The following table indicates the code for programming.

KEYBOARD DIGIT	COMMAND
0	0IPM
1	AXIS 1
2	AXIS 2
3	40 IPM
4	60 IPM
5	80 IPM
+	Plus Direction
-	Minus Direction

An example of the two-axis lathe z axis minus 40 ipm is: 2, 3, - and the readout indicates:

ANALOG-AXIS 2 DIR = IPM 40 L0000

4. Depress Cycle Start. The axis runs with the lag indication blanked.

5. Stop motion by depressing Clear. The lag which the motion was running with will be displayed and everything is reinitialized to starting conditions. Note that Clear will return routing to beginning at any time.

6. Continue as before or depress Optional Stop to leave the test.

After the last test in the AXIS2* diagnostic is completed, the display indicates:

AXIS2* - TEST COMPLETE

Error Codes

TEST/ERROR CODE	ERROR CODE DESCRIPTION
2	A false acknowledge was generated for the first axis output command.
3	A false acknowledge was generated for the first axis sense status.
4	A false acknowledge was generated for the first axis write byte.
5	A false acknowledge was generated for the first axis read byte.
6	A false acknowledge was generated for the second axis output command.
7	A false acknowledge was generated for the second axis sense status.
8	A false acknowledge was generated for the second axis write byte.
9	A false acknowledge was generated for the second axis read byte.
10	There is a stack error '55'.
11	There is a stack error 'AA'.
12	There is a stack error '00'.
13	There is a stack error when performing addressing tests.
14	There is a stack error when performing interference tests.
15	The Arithmetic and Logic Unit failed to add correctly.
16	The Arithmetic and Logic Unit failed to subtract correctly.
20	A failure occurred when testing the reference counter through the sine/cosine exclusive OR.
21	The first axis error counter failed.
22	The second axis error counter failed.
30	The 250-waveshaper interrupt calculation failed for the first axis.
31	The 250-waveshaper interrupt calculation failed for the second axis.
32	The 566-waveshaper interrupt calculation failed for the first axis.
33	The 566-waveshaper interrupt calculation failed for the second axis.
34	The 816-waveshaper interrupt calculation failed for the first axis.
35	The 816-waveshaper interrupt calculation failed for the second axis.
36	There is a 24-Correct failure for the waveshaper interrupt calculation (through 0 for an increasing waveshaper angle) for the first axis.

(Continued)

TEST/ERROR CODE	ERROR CODE DESCRIPTION
37	There is a 24-Correct failure for the waveshaper interrupt calculation (through 0 in the increasing waveshaper angle) for the second axis.
38	There is a 24-Correct failure for the waveshaper interrupt calculation (through 0 in the decreasing waveshaper angle) for the first axis.
39	There is a 24-Correct failure for the waveshaper interrupt calculation (through 0 in the decreasing waveshaper angle) for the second axis.
40	The first axis has a lead screw compensation error.
41	The second axis has a lead screw compensation error.
42	There is an error limit flag failure on the first axis.
43	There is an error limit flag failure on the second axis.
44	There is an out-of-sync flag failure on the first axis.
45	There is an out-of-sync flag failure on the second axis.
46	There is a distance zero flag failure on the first axis.
47	There is a distance zero flag failure on the second axis.
48	There is an out-of-position flag failure on the first axis.
49	There is an out-of-position flag failure on the second axis.
50	There is a distance 0 flag failure for the first axis when distance is minus 1.
51	There is a distance 0 flag failure for the second axis when distance is minus 1.
52	The loss of feedback detection circuitry failed.
53	There is an Axis Complete 1/Axis Complete 2 failure when ENAXIS1 = 1.
54	There is an Axis Complete 1/Axis Complete 2 failure when ENAXIS1 = 0.
55	There is an axis complete interrupt failure for the first axis when generated by distance 0.
56	There is an axis complete interrupt failure for the second axis when generated by distance 0.
57	There is an axis complete interrupt failure for the first axis when generated by in position.
58	There is an axis complete interrupt failure for the second axis when generated by in position.

(Continued)

TEST/ERROR CODE	ERROR CODE DESCRIPTION
60	There is a path computation error for the first axis when in the scale-of-1 with a first computation of 0 and a plus move.
61	There is a path computation error for the second axis when in the scale-of-1 with a first computation of 0 and a plus move.
62	There is a path computation error for the first axis when in the scale-of-2 with a first computation of 2 and a plus move.
63	There is a path computation error for the second axis when in the scale-of-2 with a first computation of 2 and a plus move.
64	There is a path computation error for the first axis when in the scale-of-2 with a first computation of 2 and a minus move.
65	There is a path computation error for the second axis when in the scale-of-2 with a first computation of 2 and a minus move.
66	There is a path computation error for the first axis when in the scale-of-2 with a first computation of 1 and a plus move.
67	There is a path computation error for the second axis when in the scale-of-2 with a first computation of 1 and a plus move.
68	The timed test for the first axis path computation failed.
69	The timed test for the second axis path computation failed.
70	The first circular interpolation test failed. (Checks cross-ties.)
71	The second circular interpolation test failed. (Checks cross-ties.)
72	The third circular interpolation test failed. (Checks cross-ties.)
76	The block I/O - Read test failed.
77	The block - I/O - Write test failed.
80	No error message. The hand-cranking test is described on page 19.
81	No error message. The analog exerciser is described on page 19.

THC1*

The THC1* test requires approximately 2 seconds to run. This diagnostic has the "Loop On Test When Error Is Detected" capability (mode 4).

This diagnostic has the "Loop On Test When Error Is Detected" capability (mode 4).

If Mode 4 is active and an error is detected:

1. The display indicates the slot number of the board that caused the error code.

2. The operator must depress Cycle Start 6 to 8 seconds to acknowledge the message.

3. If there is hex auxiliary data, it is also displayed and it must be acknowledged by again depressing Cycle Start 6 to 8 seconds. The test is now in the loop.

4. **To exit the loop and leave Mode 4, depress Optional Stop. The THC1* board is tested in the following sequence.**

First, the bus handshaking circuitry is exercised to ascertain that no false acknowledge occurs when doing any of the following.

OC - Output Command
SS - Sense Status
WB - Write Byte
RB - Write Byte (Threadcutting and MFO)

A complete stack test is accomplished including pattern checks, address checks, and interference checks.

When a failure occurs on a stack test, the auxiliary information is:

XX	XX	XX
Stack Address	Correct Data	Actual Data

Address:

Address	Stack
00-0F	A2
10-1F	A1
20-2F	B1

Four additions and 4 subtractions check the arithmetic unit. The auxiliary information for the arithmetic unit is:

XX	XX	XX	XX
A Input Data	B Input Data	Correct Data	Actual Data

The balance of the tests occur in the order shown below.

20 - 24 TESTS

Test 20 checks the excitation counter and sine and cosine generation. The auxiliary information is the reference counter count (hex) at the time the failure occurred.

Test 21 is a digital check on the MFO counter

The auxiliary display shows:

XX	XX	XX
01 = Did not clear 02 = Count up error 03 = Count down error	Correct Count	Actual Count

Test 22 is an operator-aided test (Mode 2) which gives a readout of:

X RE - First axis reversal - error switch selection

Z RE - Second axis reversal - error switch selection

MFO - MFO value (01 to F) as determined by the setting of the MFO potentiometer

Example: X RE 7F Z RE 7F MFO 55

*NOTE: Controls not using an analog MFO will not have this part of the display message nor will the THC1*2 board in the 1054T Control.

Test 23 is also a Mode 2 test (operator-aided). This test reads the spindle resolver angle and displays it as the spindle is hand-cranked. The display varies from 0 to hex 3E7 (0-999 decimal) oe 3E7 to 0 for each revolution of the resolver. To exit this test, depress Cycle Start.

Test 24 checks the RPM divide-by-150 counter and the interrupt generated by the counter. The test is accomplished as follows:

1. A check is made to assure that an interrupt does not exist.

2. The counter is counted 149 counts. An interrupt should still not exist.

3. The counter is counted one more count causing an interrupt to be generated.

The auxiliary information is:

XX
Auxiliary
Code

Auxiliary
Code
01 - Did not clear
02 - Set early
03 - Did not set

30-39 TESTS

The 30-39 tests generate artificial waveshaper interrupts to check previous position, present position, delta angle, and digital filter integrand calculations. The first 3 are checked with the path to the digital filter integrand blocked. Then the digital filter integrand (open loop) is allowed to build up as artificial angles are generated.

When an error occurs, the auxiliary display shows:

XX	XX	XX	XX	XX	XX
Correct Data			Actual Data		

When an error is detected in the 30 series test and Mode 4 is active, the test loop stops at the point of failure. When Cycle Start is depressed to exit the loop, the next test will be Test 40. Example:

Failure on Test 33
Loop Test = 30 through 33
When the loop is exited, tests 34-39 are skipped and the diagnostics go to Test 40

Test 32 checks the sign △ Ø and the △Ø counters: The display for an error is as follows:

00 FA XX XX 0064 YY YY

where:

00FA = correct sign △Ø
XXXX = actual sign △Ø
0064 = correct △Ø
YYYY = actual △Ø

40-43 TESTS

Tests 40 and 41 check the RPM counter. For test 41, the auxiliary information is:

XXXX	XXXX
Correct RPM Data	Actual RPM Data

Test 42 checks threadcutting indexing. The auxiliary information is:

XX
Auxiliary
Code

Auxiliary Code

01 - Index is set when it should be clear.
02 - Index did not set - increasing count.
03 - Index did not set - decreasing count.

Test 43 checks variable lead. Starting conditions are:

Filter integrand - 100
Filter remainder size - 250
Variable lead integrand - 20
Variable lead remainder size - 999

The auxiliary information is:

00 00 03 E7	XX XX XX XX
Correct Variable Lead Remainder	Actual Variable Lead Data

When the diagnostics have run to this point (through test 43) THC* - TEST COMPLETE is displayed.

50-55 TESTS

The 50 series tests are interconnect tests between the AXIS2* and the THC1* board. Any failure in the 50 series tests will produce an error message listing both the AXIS2* and the THC1* boards.

A failure of test 50 would give the following message.

02 THC1* 50 03 AXIS2*

These tests are performed only if the mating axis board has been tested. If the tests are not performed the display will indicate:

THC - AXIS* - INTERACTION NOT DONE

At the completion of test 55 (the last test performed) the display will indicate:

THC-AXIS* - INTERACTION COMPLETE

Tests 50-53 check CV and variable lead interconnection and associated multiplexers.

Test 54 which tests axis complete insures that there is no loss of pulses between successive threading blocks.

Test 55 checks the generation or CV pulses in the Test mode and ipr.

Error Codes

TEST/ERROR CODE	ERROR CODE DESCRIPTION
2	A false acknowledge was generated for the threadcutting output command.
3	A false acknowledge was generated for the threadcutting sense status.
4	A false acknowledge was generated for the threadcutting write byte.
5	A false acknowledge was generated for the threadcutting read byte.
6	A false acknowledge was generated for the MFO read byte.
10	There is a stack error '55'.
11	There is a stack error 'AA'.
12	There is a stack error '00'.
13	There is a stack error when performing addressing tests.
14	There is a stack error when performing interference tests.
15	The Arithmetic and Logic Unit failed to add correctly.
16	The Arithmetic and Logic Unit failed to subtract correctly.
20	A failure occurred when testing the reference counter through the sine/cosine exclusive OR.
21*	The digital test on the MFO counter failed.
22*	No error message - Test of MFO and reversal error. See page 23.
23	No error message. Hand-cranking routine for the spindle. See page 23.
24	The RPM counter interrupt test failed.
30	The 250-waveshaper interrupt previous angle calculation is incorrect.
31	The 250-waveshaper interrupt present angle calculation is incorrect.
32	The 250-waveshaper interrupt delta angle calculation is incorrect.
33	The 250-waveshaper interrupt filter integrand calculation is incorrect.
34	The 566-waveshaper interrupt filter integrand calculation is incorrect.
35	The 816-waveshaper interrupt filter integrand calculation is incorrect.
36	There is a 24-Correct failure for the filter integrand calculation (through 0 in the increasing waveshaper angle.

(Continued)

For the 1054T test, test 21 for the THC1 is not performed. For test 22 the MFO portion of the test is also not performed.

TEST/ERROR CODE	ERROR CODE DESCRIPTION
37	There is a 24-correct failure for the filter integrand calculation (through 0 in the decreasing waveshaper angle).
38	The 250-waveshaper interrupt filter integrand is incorrect for revolutions-per-minute over 2500 and with a multiplication factor of 1.
39	The 250-waveshaper interrupt filter integrand is incorrect for revolutions-per-minute over 2500 and with a multiplication factor of 2.
40	The RPM counter test failed.
41	Transfer of data for RPM interrupt is incorrect.
42	The threadcutting index check failed.
43	Test of the variable lead integrator failed.
50	AXIS2-THC1 CV interconnect test for inches or millimeters-per-minute failed.
51	AXIS-THC1 CV interconnect test for inches or millimeters-per-revolution failed.
52	AXIS-THC1 CV interconnect test for threadcutting failed.
53	AXIS-THC1 CV and variable lead interconnect test failed.
54	Test of axis complete interconnect between AXIS2 and THC1 failed.
55	Check for generation of IPR CV pulses for test mode on THC1 failed.

PERI1

(NOT INCLUDING THE TAPE READER SECTION)

The PERI1 board is the first board tested and establishes the integrity of the display. The display and sequence number readout are tested by displaying characters and numbers for the operator's inspection. These tests can be activated by selecting the Mode 2 operation at the start of the test sequence. The display test appears first, and it recycles until it is halted by the operator.

The sequence number readout test appears second (if present) and it also recycles until it is halted by the operator. Halting of either display is accomplished by depressing Optional Stop to indicate dissatisfaction with the accuracy of the display, or by depressing Cycle Start to indicate approval. The lamps behind these two pushbuttons blink alternately during the display tests to remind the operator of the need of button pushing. If the Sequence Number Readout option is not present, depress Cycle Start a second time to continue testing.

The spindle digital-to-analog section of the board is tested automatically. Any error is reported and testing resumes until the 11 tests described on page 28 are completed.

Display

All dots of the 5 x 7 matrix display are lighted. Check that all dots are successfully lighted.

The characters "H," "#," and "I" (which together use all dots in the 5 x 7 matrix) are shifted one at a time across the display, left to right. Observe that each character is correctly displayed in each position and that no extraneous characters appear.

Letters, numbers, and 10 special characters are displayed sequentially.

Message Codes

10 - The readout is faulty.

A. Optional Stop was depressed in Mode 2 test.

B. The block I/O test caused false acknowledge during normal testing of the PERI board.

14-There is a false acknowledge during write data (ends test).

Sequence Number Readout (Optional)

The digit "8" is displayed in all positions, to demonstrate that all bars of the 7-bar matrix are operating.

Digits 0-9 are shifted individually across the readout to demonstrate the decoding and display ability of each digit position.

Message Codes

20-The readout is faulty (Optional Stop was depressed).

24-There is a false acknowledge on write data (ends test).

Spindle Digital-to-Analog Section Test (All Modes)

Each sub-test of the spindle digital-analizer test consists of sending Control data to the board (write data), then sensing its status 4000 times to determine, by repeated sampling, the fraction of the time that a status bit is in the active state. The total number of times the bit is found to be active is compared with the nominal value, with a tolerance of +5.9% (1/17) to allow for uncertainty in the sampling process. In those tests where the tested bit should never be active, the tolerance is 0. In the outline below, message codes are listed with each test description.

The test is run twice. The first pass is a check of decimal operation; the second pass is a check of binary operation. Error codes are the same for both; however, an auxiliary message is given as follows:

01 - for decimal
02 - for binary

Spindle D/A Section Tests - Continued

SUBROUTINE	FUNCTION	ERROR CODE PRODUCED	SUMMARY
Positive direction not run, count 333	(333 is significant only to the extent that it causes system exchange lines 4 and 5 to have opposite states in the 2 data bytes) Test ON POS DIR status bit (bit 0) for 0.	42	ON POS DIR was not gated off by not run.
Positive direction, not run, count 333	Check ON NEG DIR status bit (bit 4) for 0.	44	ON NEG DIR active for positive direction not run command.
Positive direction, run, count 369	Test ON NEG DIR bit for 0.	46	ON NEG DIR active when positive direction was commanded.
Positive direction, run, count 369	As above, but check ON POS DIR versus limits.	47 48	POS less than the low limit. POS greater than the high limit.
Positive direction, run, count 693	Test ON POS DIR bit (Counts 369, 693, and 936 were selected to partially check the independence of the bits being transmitted and stored).	49 50	POS less than the low limit. POS greater than the high limit.
Positive direction, run, count 936	Test ON POS DIR bit.	51 52	POS less than the low limit. POS greater than the high limit.
Negative direction, not run, count 999	Check ON NEG DIR bit for 0.	54	ON NEG DIR not gated off by not run command.
Negative direction, run, count 999	Check ON POS DIR bit for 0.	56	ON POS DIR not gated off by negative direction command.
Negative direction, run, count 999	Test ON NEG DIR bit	57 58	NEG less than the low limit. NEG greater than the high limit.
Send single byte	NEG should be inactive even though the Command Interval flip-flop is set (99.9% probability).	60	ON NEG DIR not gated off by the Count Enable flip-flop clearing.
Positive direction, run, count 999.	Then send single byte. POS should be inactive even though the Command Interval flip-flop is set (99.9% probability).	62	ON POS DIR not gated off by the Count Enable flip-flop clearing.

PERI1

Other message codes are:

Code 33-False acknowledge during sense status (ends test).
Code 34-False acknowledge during write data (ends test).

MAAU1

(Microprogrammed Auxiliary Arithmetic Unit Board)

The MAAU1 test requires approximately 2 seconds to run. This diagnostic has the "Loop On Test When Error Is Detected" capability (Mode 4).

If Mode 4 is active and an error is detected:

1. The display indicates the slot number of the board that caused the error code.

2. The operator must depress Cycle Start 6 to 8 seconds to acknowledge the message.

3. If there is hex auxiliary data, it is also displayed and must be acknowledged by again depressing Cycle Start 6 to 8 seconds. The test is now in the loop.

4. To exit the loop and leave Mode 4, depress Optional Stop.

The MAAU1 board is tested in the following sequence.

First the bus handshaking circuitry is exercised to ascertain that no false acknowledge occurs when doing any of the following:

OC	Output Command
SS	Sense Status
WW	Write Word
RW	Read Word

A complete stack test is accomplished including pattern checks, address checks, and interference checks.

When a failure occurs on a stack test, the auxiliary display shows:

XX	XXXX	XXXX
Stack	Correct	Actual
Address*	Data	Data

*Address:

Address	Stack
00-0F	C
10-1F	C
20-2F	B
30-3F	A

BASIC FUNCTION CHECKS

Next, the basic functions of the board are checked in the following sequence. (The Auxiliary readout shows the actual test result; correct results are listed below).

TEST	CORRECT RESULT
*10 + N	91AEB3C0000E91AEB3C0
Modulus Add1 Sub-routine	21 11 F5 E0
Shift left 8 bits	A500
Multiplication	00 60 68 86 71 59 00 00
Square Root	56 78 12 34 1A BC 00 00
Division	56 78 00 BC 00 00 00 00

ACTUAL ROUTINE CHECKS

Then actual routines are checked as follows:

ASCII to binary Binary to ASCII
Constant Surface Speeds
Modulus
Direct RPM
Inch-Metric Conversions
Final Lead Calculation

Correct result for each is as follows:

TEST	CORRECT RESULT
28	04 2A 75 88
29	36 39 38 39 31 34 36 34
30	36 39 38 39 31 34 36 34
32	00 02 00 48 C8 51
33	30 30 32 00 48 C8 51
34	00 02
35	30 30 02
36	00 8A 1D DE 00 01
37	00 1B 9F 92 00 02
38	00 F9
39	32 34 39
40	00 91 A2 B3 00 91
41	00 91 A2 B3 00 6D
42	00 91 A2 B3 00 44
43	02 E3 D4 1F 00 1D
44	01 71 EA 0F 00 4F
45	00 72 AC 75 00 25
46	00 39 56 3A 00 A4
47	02 46 8A 0E 00 12
48	05 C7 A8 3E 00 28
49	00 E5 58 EA 00 38
50	15 39 97 93

If the MAAU1 fails to complete any routine, the standard error code is read out and an auxiliary message of '31' indicates failure to complete (still busy).

SUMMARY OF MAAU1 CHECKS

A summary of all MAAU1 checks is listed below.

CODE	ERROR CODE DESCRIPTION
2	False acknowledge for output command.
3	False acknowledge for sense status.
4	False acknowledge for write word.
5	False acknowledge for read word.
10	There is a stack error for '5555'.
11	There is a stack error for 'AAAA'.
12	There is a stack error for '0000'.
13	There is a stack error for the address test.
14	There is a stack error for the interference test.
19	The *10 + N calculation failed.
21	Modulus ADD1 subroutine calculation failed.
23	Shift left 8 bits test failed.
24	Multiplication test failed.
25	Square root test failed.
20	Division test failed.
28	ASCII to binary calculation failed.
29	Binary to ASCII calculation unpacked failed.
30	Binary to ASCII calculation packed failed.
31	Auxiliary message-Failure to complete calculation.
32	CSS - 1st calculation test failed.
33	CSS - 1st calculation test ASCII result failed.
34	CSS - update calculation test binary result failed.
35	CSS - update calculation test ASCII result failed.
36	IPM modulation calculation test result failed.
37	IPR modulation calculation test failed.
38	Direct RPM calculation test binary failed.
39	Direct RPM calculation test ASCII failed.
40	Inch-to-Inch 0.1 to 0.2 positive remainder test failed.
41	Inch-to-Inch 0.1 to 0.2 negative remainder test failed.
42	Metric-to-Metric 1mm to 2mm test failed.
43	Inch-to-Metric (1mm) test failed.
44	Inch-to-Metric (2mm) test failed.
45	Metric-to-Inch (0.1 inch) test failed.
46	Metric-to-Inch (0.2 inch) test failed.
47	Inch or Metric (.2 to .1 or 2 to 1) test failed.
48	Inch-to-Metric 0.2 to 1mm test failed.
49	Metric-to-Inch 2mm to 0.1 test failed.
50	Final Lead calculation test failed.

PCI1, PCI2

The PCI1 and PCI2 tests operate in an identical manner. (The following examples are taken from the PCI1 test.) The PCI test requires approximately 80 seconds to run. This diagnostic has the "Loop On Test When Error is Detected" capability (Mode 4).

If Mode 4 is active and an error is detected:

1. The display indicates the slot number of the board that caused the error code.

2. The operator must depress Cycle Start 6 to 8 seconds to acknowledge the message.

3. If there is octal auxiliary data, it is also displayed and must be acknowledged by again depressing Cycle Start 6 to 8 seconds. The test is now in the loop.

4. To exit the loop and leave Mode 4, depress Optional Stop.

The PCI board is tested in the following sequence: When the test is initiated, the display shows:

'PCI1 TEST IN PROGRESS'

The bus handshaking circuitry is then exercised to ascertain that no false acknowledge occurs when doing any of the following.

OC - Output Command
SS - Sense Status
WW - Write Word
RW - Read Word

A complete PCI memory checkout is then performed (Tests 10 - 14). The memory checkout includes pattern test, addressing tests, and interference tests.

Note: The PCI Memory Tests destroy the data previously stored in PCI memory. The PCI memory must be reloaded after running the diagnostics.

When a memory test failure occurs, auxiliary data is displayed. The format, also used for all PCI tests which display auxiliary data, is as follows:

XXXX	XXX	XXX
PCI Memory Address	Correct Data	Actual Data

Both the PCI Memory Address and the Memory Data are in octal format to aid when troubleshooting the PCI board with a teletype connected to the PCI.

The balance of the tests occur in the order shown below:

20 - 25 Tests

Test 20 and 21 check if the PCI stops and restarts its internal clock upon command.

Test 22 checks if the PCI board generates interrupts on the ASR bus.

Test 23 checks if the PCI board disables the generation of interrupts at the board.

Tests 24 and 25 check if the PCI board generates and releases a priority (digital) interrupt.

No auxiliary data is provided for this series of tests.

40 - 56 Tests

Tests 40 and 42 check for correct solution of simple relays. All types of coil contact configurations are tested with all combinations of contact states.

Test 44 checks for correct solution of all configurations of latch relays.

Test 46 checks for correct solution of all configurations of 0.1 - Sec. and 1.0 - Sec. timers.

Test 48 checks the counting of both types of timers.

Test 50 checks for correct solution of the up-down counter.

Test 52 checks the counting function of the counter.

Test 54 checks for correct solution of the arithmetic functions.

Test 56 checks the various arithmetic functions for correct calculations.

Tests 40 - 56 provide auxiliary data upon detection of a test error.

60 - 64 Tests

Test 60 checks for correct relay data storage in all locations on the PCI board, up to the number of programmable relays selected by jumper selection on the PCI board. Auxiliary data is provided upon test error.

Test 62 is an operator-aided test requiring that Mode 2 is active. The number of programmable relays selected by jumper connection on the PCI board is displayed on the readout. Exit Test 62 by depressing Cycle Start (to indicate that the displayed data is correct) or Optional Stop (to indicate that the displayed data is incorrect).

Test 64 checks if PCI board correctly accesses the extended relay state table and the extended input state table. Auxiliary data is provided upon test error.

70 - 77 Tests (Serial I/O Tests)

The remaining tests (Tests 70 - 77) check the operation of the Serial I/O port on the PCI board. These are operator-aided tests, requiring that Mode 2 be active, and that a Teletype/TermiNet printer or a Programmer's Panel be connected to the Serial I/O port on the PCI.

If Mode 2 is active, the display shows:

'PCI SERIAL I/O TESTS, NEXT'

If some device is connected to the serial I/O port on the PCI board, continue by depressing Next.

It it is desired to skip these tests (for example, if no device is available with which to perform these tests), the serial I/O tests may be skipped by depressing Cycle Start.

If the PCI serial I/O tests are being performed for the first time since the system diagnostics were loaded, the PCI test will ask the operator to indicate the type of device connected to the PCI serial I/O port by displaying:

'PRESS 2 FOR PROG PANEL, 1 OTHER'

The operator must respond by depressing either keyboard digit 1 to indicate a Teletype or TermiNet printer, or keyboard digit 2 to indicate a programmer's panel. Once entered, the information is retained and cannot be changed as long as the system diagnostic software remains loaded.

Tests 70 - 73 check the read word, read block, write word, and write block functions with the typewriter. In each case, instructions are provided as follows:

'TYPE: * 00 n XXXX ...', where n, XXXX, ... indicate octal data

The operator must type the instruction exactly as it appears on the display. Once the instruction has been completed, acknowledge by depressing Next.

If further instructions are required, the appropriate instruction will be displayed. After instructions have been acknowledged, the display shows the correct data which should appear on the typewriter:

'DATA: xxx yyy ...', where xxx, yyy, ... indicate octal data

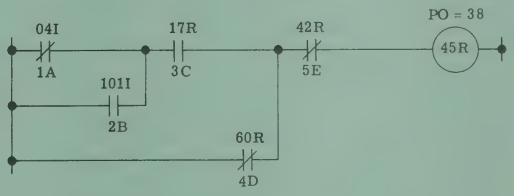
If the data on the typewriter is correct, depress Cycle Start. If the data is in error, depress Optional Stop.

Tests 76 and 77 require the Programmer's Panel. The display announces each test:

'PCI I/O TEST 76 (PROG PANEL)'

The operator must read a relay using the programmer's panel, indicating correct operation or failure by depressing Cycle Start (correct operation) or Optional Stop (failure). For detailed instructions on use of the Programmer's Panel, see GEK-36070, Section 2.

The relay should be of the following configuration:



Test 77 is announced by the display in the same manner as Test 76. Test 77 checks data write by the programmer's panel. The operator may enter any relay configuration by using the programmer's panel, then verify that the desired change is shown by the programmer's panel. Exit Test 77 by depressing Cycle Start (success) or Optional Stop (failure).

Error Codes

TEST/ERROR CODE	ERROR CODE DESCRIPTION
2	A false acknowledge was generated for the PCI output command.
3	A false acknowledge was generated for the PCI sense status.
4	A false acknowledge was generated for the PCI write word.
5	A false acknowledge was generated for the PCI read word.
10	There is a PCI memory pattern test failure '000'.
11	There is a PCI memory pattern test failure '0AA'.
12	There is a PCI memory pattern test failure '155'.
13	There is a PCI memory addressing test failure.
14	There is a PCI memory interference test failure.
20	The PCI failed to start the internal board clock.
21	The PCI failed to stop the internal board clock.
22	The PCI failed to generate interrupt on ASR line.
23	The PCI failed to disable PCI interrupts on ASR line.
24	The PCI failed to generate priority (digital) interrupt.
25	The PCI failed to release priority (digital) interrupt.
40	The PCI failed to solve simple relay (input contacts).
42	The PCI failed to solve simple relay (relay contacts).
44	The PCI failed to solve latch relay.
46	The PCI failed to solve timer relay.
48	The timer failed to count.
50	The PCI failed to solve counter relay.
52	The counter failed to count.
54	The PCI failed to solve arithmetic relay.
56	The arithmetic function failed the calculation test.
60	There is a relay storage test failure.
62	No error message. Displays number of programmable relays. See page
64	There is a failure when accessing the extended relay table and/or extended input table.
70	No error message. The TTY read word test. See page 33.
71	No error message. The TTY read block test. See page 33.
72	No error message. The TTY write word test. See page 33.
73	No error message. The TTY write block test. See page 33.
76	No error message. The Programmer's Panel read data test. See page 33.
77	No error message. The Programmer's Panel write data test. See page 33.

CPSI1

The CPSI1 test is an operator-aided diagnostic; Mode 2 must be active to run this test.

If Mode 2 is active, the display shows:

PRESS CYCLE START FOR CPSI1 TEST

To perform the CPSI1 test, depress Cycle Start to proceed. If the CPSI1 board is not present, depress Optional Stop to skip this test.

The CPSI1 is tested in the following manner:

1. Both the serial I/O and the control panel interface sections of the CPSI1 are exercised to ascertain that no false acknowledge occurs. Tests 2-9 are false acknowledge tests. No auxiliary error data is provided.

2. The serial I/O port tests require that a terminal (such as a Teletype or TermiNet printer) be connected to the serial I/O port at the rear of the Control. The display instructs the operator:

PRESS NEXT FOR SERIAL I/O TESTS
OR PRESS CYCLE START IF NO TTY

Depress the Next pushbutton if a terminal is connected. If none is available, press Cycle Start to skip these tests.

The serial I/O port is tested by asking the operator to type nine characters on the terminal keyboard:

TYPE: A, B, D, H, P, 1, 2, 4, 8

Tests 10-11 check the serial I/O port status before and after each character is read. Test 12 checks whether the character contains correct data. If data is correct, the character is echoed back to the terminal to be printed. Tests 13-15 check the serial I/O port status before, during, and after each character is written to the terminal.

Auxiliary data for tests 10-11, 13-15 is as follows:

XX	XX
Correct Status Bits	Actual Status Bits

The 2 hex characters represent the 8-bit binary status byte. The meaning of each bit in the status byte is detailed in GEK-45686, page 13, which immediately follows this section.

Auxiliary data for Test 12 is as follows:

XX	XX
Correct Data	Actual Data

If any character does not print on the terminal after being typed, check to see if an error has been detected. If no error was detected, yet the character was not printed, the CPSI1 has no way to receive data from the terminal. Depress Optional Stop to discontinue the test.

The TTY test is run at 110 Baud (10 char/sec.). The display instructs the operator to type a string of characters on the Teletype keyboard. Each character is tested as it is received (Test 14), and then sent back to the Teletype to be printed. Auxiliary data is provided as shown:

XX	XX
Correct Data	Actual Data

3. The remaining tests check the Computer Access Panel and its interface circuitry on the CPSI1. These tests require that an access panel be connected to the CPSI1 board. The display shows:

PRESS NEXT FOR ACCESS PANEL TEST

Depress Next to proceed with the access panel tests. If no access panel is available, depress Optional Stop to skip these tests.

The access panel tests require the operator to verify that each test is performed correctly.

A. The display shows: CPNL SELECTOR SWITCH TESTS, NEXT. Depress Next when ready to proceed. The display then instructs the operator to turn the selector switch on the access panel to one position. If the switch position is recognized correctly, the display indicates the next position to be tested. Any position may be skipped by depressing Next. Depress Optional Stop to terminate testing.

B. The display shows: CLEAR ALL DATA SW BITS, NEXT. Raise bit switches 0-15 to the logic "0" position, then depress Next. The display then instructs the operator to depress each bit switch. Only the indicated switch bit must be depressed; all others must be in the logic "0" position. If the switch bit is recognized correctly, the display indicates the next switch bit to be tested. Any switch bit may be skipped by depressing Next.

C. The display shows: EXAMINE MEM LOC 0030, NEXT. Load memory address 0030 on the access panel, then select memory data. Depress Next on the Control. The access panel data display is checked by shifting numbers from right to left across the display. The same data is also displayed on the Control display. If the access panel data display is correct, depress Cycle Start to go to next test. To indicate an error and terminate testing, depress Optional Stop.

D. Three breakpoint tests are now performed. The display shows: LOAD BREAKPOINT = XXXX, NEXT. Enter the breakpoint indicated and acknowledge by depressing Next. The display indicates the correct value of the program counter when the program halts: HALT AT XXXX, PRESS RUN. The operator must press Run to continue. Write-only breakpoint and auxiliary (= breakpoint override) tests are also performed

E. The display shows: PRESS HALT, THEN RUN, NEXT. Depress Halt on the access panel and verify that the program has halted. Then depress Run on the access panel and verify that the program restarts. To continue, depress Next on the Control.

F. The display shows: EXAMINE REGISTER 0, NEXT. Select Register 0 on the selector switch. Depress Next. The program halts with Register 0 containing 5555. The display shows: PRESS SINGLE INSTR, ACO = 0, THEN RUN. Depress Single Instruction and verify that Register 0 now contains 0000. Depress Run on the access panel to continue.

G. The display shows: SELECT MEM ADDR, NEXT. Turn the selector switch to memory address, then acknowledge by depressing Next on the Control. The display then instructs the operator: PRESS INCR MEM ADDR. Depress Increment Memory Address on the access panel and verify that the memory address is incremented. If the switch is recognized correctly, the testing is complete. The operator may terminate testing by depressing Next on the Control.

Error Codes

CODE	ERROR CODE DESCRIPTION
2	There is a false acknowledge during ASR output command.
3	There is a false acknowledge during ASR sense status.
4	There is a false acknowledge during ASR write byte.
5	There is a false acknowledge during ASR read byte.
6	There is a false acknowledge during CPNL output command.
7	There is a false acknowledge during CPNL sense status.
8	There is a false acknowledge during CPNL write word.
9	There is a false acknowledge during CPNL read word.
10	There is a serial I/O status error prior to transmission (READ).
11	There is a serial I/O status error following transmission (READ).
12	There is a serial I/O data transmission error.
13	There is a serial I/O status error prior to transmission (WRITE).
14	There is a serial I/O status error during transmission (WRITE).
15	There is a serial I/O status error following transmission (WRITE).

GEK-45668C

INSTRUCTIONS

1050
COMPUTER
ACCESS PANEL

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GENERAL ELECTRIC

JANUARY, 1977

UNLESS OTHERWISE SPECIFIED USE THE FOLLOWING					TITLE
AVOID FRACTIONS	DECIMALS	TOLERANCES ON MACHINED DIMENSIONS			1050T - 2 AXIS LATHE
	✓	FRACTIONS ±	DECIMALS ±	ANGLES ±	FIRST MADE FOR 3N8100NC100A2
					INSTALLATION DIAG. 3N8100MD103X1

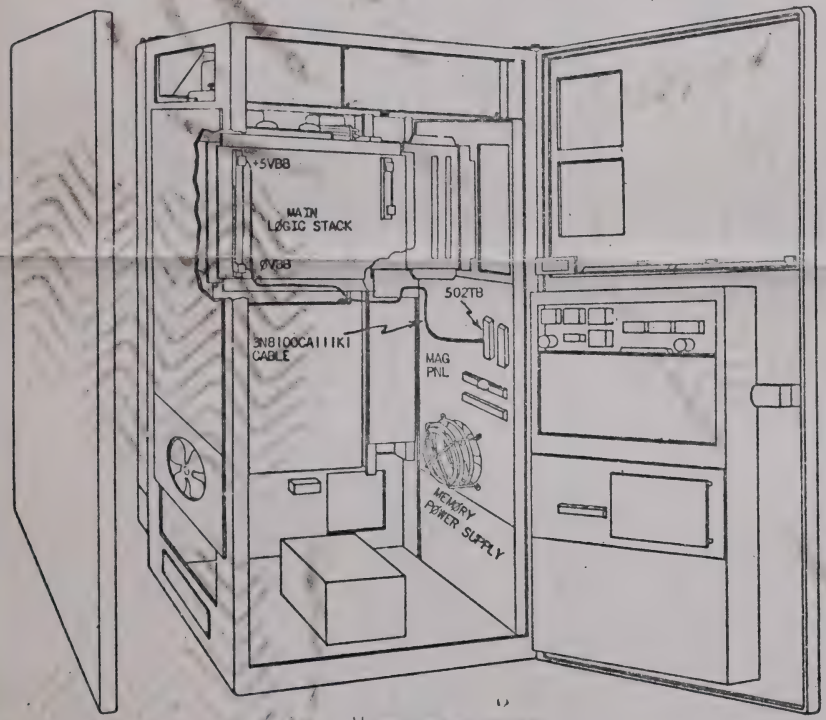
VELØCITY LØØP JUMPER CABLE MØD.

INSTRUCTIØNS FØR 3N8100MD103X1:

1. CØNNECT 114PL ØN CABLE END TØ 114PL ØN CUSTØMER PNL. PUTTING FIRST PIN (PIN5) ØF CABLE CØNNECTØR ØN PIN 5 ØF CUST.PNL. 114PL AND LAST PIN (PIN 19) ØF CABLE CØNN. ØN BØTTØM-MØST CUST. PNL. 114PL PIN 19. NØTE THAT PIN 5 ØF CABLE CØNN. HAS A WIRE AND PIN 19 DØESN'T.
2. RØUTE CABLE AS PER SKETCH AND CØNNECT TAGGED ENDS TØ 502TB ØN MAG.PNL. AS PER TAG.
3. INSTALL NAMEPLATE TØ EDGE ØF TUMBLE BØX BELØW ØTHER NAMEPLATES.

PARTS LIST

DESCRIPTIØN	CAT. NUMBER.	QTY.
NAMEPLATE - CABLE	259A9619P101 3N8100CA111K1	1 1



FRØNT VIEW ØF ENCLØSURE
DØØR ØPEN

REFERENCE SHEET NØ. 553

REVISIONS		PRINTS TO
1	FEB 07 1978	30V1A
2	JUN 28 1978	

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ISSUED	APPROVED		
AUG 1 1977	R. R. Herter	INDUSTRIAL CONT. PROD. WAYNESBORO, VA.	47C286079

1050 COMPUTER ACCESS PANEL

The 1050 Computer Access Panel facilitates troubleshooting a Mark Century* 1050 Control. The panel is an interface between the user and the 1050 Control. With it the user can observe and modify selected processor and memory data.

The access panel does not replace the diagnostic tapes, but is an additional troubleshooting device. The access panel also has interface circuitry for an Asynchronous Send/Receive (ASR) port, either voltage or current interface, such as a TermiNet* keyboard-printer or teletype.

INSTALLATION

The front and rear cover plates for the access panel must be removed before operating the panel. To do this, unsnap the 8 black fasteners. Take care when removing these covers because the 2 cables located in the rear of the panel may come out when the rear cover is removed. The connector pins on these cables could be damaged if the cables should swing free and strike something.

A storage space is provided in the rear of the Computer Access Panel for the CPSI1 board if it is used with the Computer Access Panel.

If any apparent damage exists as a result of shipping, it should be reported to the carrier immediately. Also, notify the General Electric Company.

Inspect the jumpers on the CPSI1 board to assure that they agree with the following table. Elementary diagrams for the panel are 44C285806.

Table 1.
JUMPERS

LOCATION	FUNCTION	IN	ELEMENTARY SHEET NUMBER
A09 1-14	ASR Disable	Yes, if using ASR Interface on CPU1*	1
M02 4-5	Position True Interrupt for CPU1A	Yes, if CPU1 is in the system; No, CPU2	3
A09 5-10	UAR/T Clock	Yes	4
A09 6-7-8	UAR/T Clock	Yes	4
A09 4-9-11	UAR/T Clock	Yes	4
A09 2-13 A09 3-12	Programmable Baud Rate Programmable Baud Rate	See Table on Programming Baud Rate in ASR Interface Section, page 11.	4
L11 A-B	UNB**	Yes	4
M02 2-7	Timer	Yes	8
M02 1-8	Timer	Yes	8
A03 1-8	SPRIF signal	No	8
A03 4-5	SCOPESYNC/Inhibit BPHALT	No	8
A03 3-5	SCOPESYNC AUXDN/Inhibit BPHALT	Yes	8
A03 3-6	AUXDN IOSPARE 2	No	8

(Continued)

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**If the CPU1 printed-circuit board (which has its own ASR interface) is in the system, but the CPSI1 ASR interface is desired, ASR on CPU1 must be disabled by removing I.C. packages R14 and R15.

***UNB (UNBLOCK) With jumper removed, the terminal connected to the CPSI1 serial part can be checked by ECHO PIEX operation of the terminal.

Table 1.
JUMPERS

Continued

LOCATION	FUNCTION	IN	ELEMENTARY SHEET NUMBER
A03 3-2	AUXDN IOSPARE	No	8
A03 7-2	SPAREIF IOSPARE	No	8
M02 3-6	REFSHREQ	Yes	11
J13 1-2	OFFLINE	No	11
L11 A-B	UNBLOCK ECHOPLEX	Yes	4

Once the CPSI1 board has been inspected, make sure that the Control logic power is off.

WARNING

Hazardous voltages. Servicing of this Control should be referred to an authorized service technician.

Then insert the CPSI1 board into any available slot in the logic rack. Connect the cables from the access panel to the board as shown on the connectors. The Upper Plug (UPL) and the Lower Plug (LPL) are located in the access panel. The Middle Plug (MPL) is located in the Control (ASR Interface Cable). The readouts on the access panel should light, verifying that Control logic power is on. The Control will not begin to operate as it would if the panel was not plugged in. Instead, the Control will wait for a command from the access panel to run.

Before depressing any pushbuttons or switches on the access panel, rotate the Display Selector switch and verify the data shown in Table 2 below. If the data on the display agrees with that in the table, the Control has come to the Initialization state. The Control must always be initialized before it can start operating. This state is forced by circuitry in the power supply, regulator board, and the central processor unit when the Control is turned on. Without the access panel, initialization cannot be detected by the operator as the Control begins operating as soon as this state is achieved.

Table 2.
INITIALIZATION STATE

DISPLAY SELECTOR SWITCH POSITION	DATA IN DATA DISPLAY	
BREAKPOINT	FFFF	
RO	0000	
R1	0000	
R2	0000	
R3	0000	
PROG CNTR	FFFE	
NEXT INST	21FD	
RALU Flags	0001	
Stack	0000	
MEM ADRS	0000	
MEM DATA (#)	----	Data that was in that location (location 0000) before the Control turned off if memory was retained.

Note: The program counter display will hold the value of the program counter except when the Display Selector switch is in the MEMORY DATA position. Then it will hold the memory address being accessed by the panel.

After the data in Table 2 has been verified, the Control is ready to run. If there is an executive program tape loaded in the Control, depress the Run pushbutton to execute that program. If there is no program loaded, place a tape on the Control's tape reader, and start the reader by depressing the Load Tape pushbutton on the panel. (An executive tape may not be loaded by the conventional method with the access panel connected to the Control.)

After the tape has been loaded, the Control begins executing the program. To stop the program, depress the Halt switch. To restart the program, simply depress the Run pushbutton.

When the Control halts of its own accord while operating an executive program, it has encountered an error condition and it should be initialized. Initializing clears several of the error conditions which may exist in the system. If initializing the Control does not clear the error, turning the Control off and back on, which forces a hardware clear, may eliminate the problem.

ALTERING MEMORY CONTENTS

As stated in the introduction, data may be observed and altered with the access panel. By setting an address on the Data switches, rotating the Display selector to MEMORY ADDRESS, and depressing the Load Data pushbutton, the panel is set to access a particular address in memory. This address appears on the Data display when the Load Data switch is depressed. By rotating the Data Display switch to the MEMORY DATA position, the contents of that location in memory now appear in the data display and the memory address itself is also shown in the Program Counter Display for quick reference.

To alter the data displayed, set the Data switches to correspond to the desired data and depress the Load Data switch. This new data now appears on the Data Display and has been entered into the selected memory location in the main memory.

To write a program into the memory, proceed as follows. Select a location for your first instruction as described above. Set the Data switches to correspond with your first instruction, set the Rotary switch to the MEMORY DATA position, and depress the Load Data switch. The instruction is now stored in the Control's memory and is displayed in the Data Display. Depress the Increment Memory Address switch once to access the next higher addressed location in memory, and enter your next instruction in the same manner as the previous one. This procedure can be used to store an entire program or to alter an existing one.

EXECUTING A PROGRAM, INSTRUCTION BY INSTRUCTION (SINGLE STEPPING)

Set the address of the first instruction on the Data switches, set the Rotary switch to PROGRAM COUNTER, depress the Load Data switch, and turn the Rotary switch to NEXT INSTRUCTION. The program counter display now holds the value of the program counter (which was just selected) and the Data display holds the instruction found at that location. It may be necessary to disable interrupts before executing a single instruction. To do this, set the Rotary switch to RALU FLAGS and load a zero into the IEN bit. Take care not to alter any other bit location. Now return the Rotary switch to the NEXT INSTRUCTION location and depress the Single Instruction switch once. This causes the presently displayed instruction to be executed, and increments the program counter by one. The new program counter value and next instruction to be executed are displayed on the access panel. The IEN bit should be restored to its original state prior to depressing the Run pushbutton. Depressing the Run pushbutton at any time allows the Control to execute a new instruction as soon as it completes the one it is presently executing. Depressing the Halt or Single Instruction pushbutton halts the Control and gives control of the program back to the operator.

STOPPING A PROGRAM ON A PARTICULAR INSTRUCTION (SETTING A BREAKPOINT)

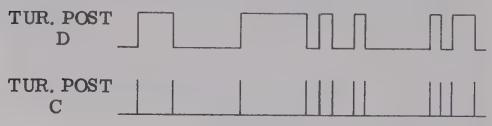
To stop a program at a particular instruction, a breakpoint must be set on that instruction. The access panel can be used to set the breakpoint on the location in memory where that instruction is stored. This forces hardware in the access panel to remember a particular address of a memory location. Any time the Control accesses that memory location, it will halt if the breakpoint halt circuit has not been disabled. (This feature is described later, page 4).

To set a breakpoint, select the location address on the Data switches, set the Rotary switch to the BREAKPOINT position, and depress the Load Data switch. The access panel (CPSI1 board) now remembers that address and displays it on the Data display.

If the system halts because it has encountered a breakpoint when fetching an instruction which does not modify the program counter, then the program counter value displayed is 1 greater than the value of the location at which the breakpoint was set. This is because the Control increments the program counter after each fetch of a new instruction and does not halt until after it has executed that instruction. If the instruction which was executed modified the program counter (e.g., a jump instruction), then the program counter display will hold the programmed value. To continue from a breakpoint halt, depress the Run, Single Instruction, or Initialize switch, whichever is desired. Setting the breakpoint value equal to FFFF will always deactivate it.

USING A BREAKPOINT TO SYNC A SCOPE

To use a breakpoint as a scope sync, set a breakpoint as outlined above and depress the Auxiliary switch, which is a latching switch. This permits a pulse at turret post C at the handle end of the CPSI1 board every time the system encounters that breakpoint, but inhibits the system from halting. This allows you to operate the program in its normal manner and observe different signals of interest at a certain point in the program. Also there is a signal at turret post D called WDNRD which changes level with each breakpoint encountered instead of pulsing as the signal at turret post C.



USING A BREAKPOINT TO DETECT WHEN A LOCATION IN MEMORY IS BEING ACCESSED IN SUCH A WAY THAT ITS CONTENTS COULD BE ALTERED

The contents of a memory location are never changed when reading an instruction or a data word. Only storing data into a memory location during program execution involves writing into the memory. Therefore, to detect when a memory location can have its contents altered, set a breakpoint as outlined on page 3, and depress the Breakpoint Write Only switch. This halts the Control only when that location is accessed in such a way as to write into it.

If the Auxiliary switch is depressed, the system produces a pulse at turret post "C" rather than halting.

OPERATOR'S DEVICES

The following outline lists the operator's devices located on the access panel and their function. See Figure 1.

Device	Use
Program Counter (#) Memory Address	Displays in 4 hex digits the current value of the program counter with the following 2 exceptions. 1. Display selector in CPNL OFF position - Meaningless. 2. Display selector in MEM DATA position - Displays the address in memory being accessed by the panel and the data found at that address is shown on the Data display.
Data display	Displays the data selected by the Display Selector rotary switch in 4 hex digits and 16 binary bits (LED's). For convenience, the 7 dedicated RALU flags are labeled on the access panel above their respective binary bits. (Refer to RALU flags, page 6.)
Parity Error light	Lights when a memory parity error occurs.
Load Tape switch	Depressing this switch causes the tape reader to read a binary tape. (This switch can only be used to load a software program, not a part program.)
Single Instruction switch	Each depression of this switch causes the central processor unit to execute the instruction pointed to by the program counter and to increment the program counter by 1. This switch may not function properly if interrupts are not disabled. Refer to "Executing a Program, Instruction by Instruction", page 3.

(Continued)

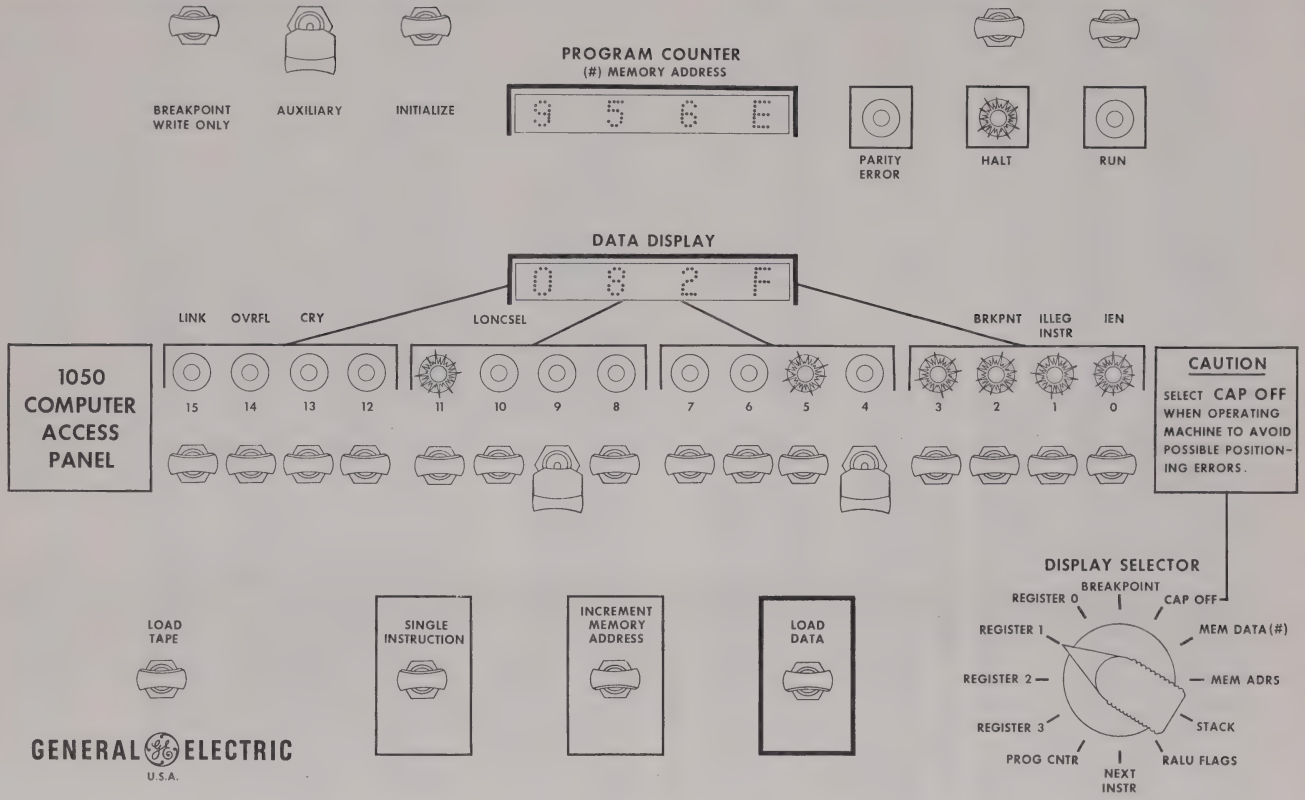


Figure 1.
OPERATOR'S DEVICES

LED

LED that is on.

The above figure shows the operator's devices located on the Access Panel. The fact that some of the lights are on has no significance except to show the correlation between the numbers shown in the Data display and the corresponding LED's that would also be on.

Device	Use
Increment Memory Address switch	Each depression of this switch causes the memory address currently being remembered by the panel for access by the Memory Address position on the Display Selector switch to be incremented by 1.
Load Data switch	Depressing this switch causes the data selected by the 16 Data Display switches to be loaded or forced into whatever is selected on the Display Selector switch at the time.
Display Selector switch	Selects what will be displayed on the Data display. (See Program Counter (#) Memory Address display and Data display.) CPNL OFF position Data on both displays will be whatever they were just prior to turning CPNL off. Data shown is not the current values. MEM DATA (#) position Memory data appears on the Data Display; the address (location) of the memory data being displayed is shown on the Program Counter display. NOTE: In all other display selector positions, the Program Counter display holds the current value of the program counter. MEM ADRS position The memory address currently being looked at or accessed by the access panel is displayed on the Data display. This position on the switch is used to select a location in memory. The data at that location may then be accessed by selecting MEM DATA (#). The data itself is then displayed on the Data Display, and the address of the location appears on the Program Counter display. STACK position The contents of the top location of the stack are displayed in the Data Display. (The stack holds 16 words of data, each 16 bits long.) All words enter or leave the stack through its top location. Each time a new word enters or leaves (is pushed onto or pulled from the stack) it pushes down or pulls up all the other words in the stack. When pushing down, the bottom word is pushed out, never to be retrieved. When pulling up, the bottom word is filled with zeros. RALU FLAGS position The RALU flags and system status bits are displayed on the data display. The labeled bits are as follows: IEN bit Interrupts enabled - Enables priority interrupts.

(Continued)

Device	Use
Display Selector switch (Continued)	ILLEG INSTR bit The central processor unit has attempted to execute an instruction which it could not successfully decode into a recognizable instruction. The display program counter value -1, identifies the location of the illegal instruction. BRKPNT bit A breakpoint has been encountered. (See the section on Breakpoint, page 4). LONCSEL bit (CPU1/CPU2 only) Link overflow, not carry select - When a 1, the link and overflow bits have been selected for use with branch and shift instructions. When 0, the carry bit is selected and the link bit is not used in shift and rotate instructions. CRY bit The Carry bit sets when the Carry flip-flop sets. This occurs when a carry operation takes place while the Control is adding, and it also occurs when a borrow operation does not take place when the Control is subtracting. OVERFL bit The overflow bit is a 1 when an overflow occurs (carry from bit 14 or 15 but not both) when arithmetic calculations are being performed. LINK bit (CPU1/CPU2 only) The link bit is a 1 when a 1 is forced into the link bit on shift and rotate instructions. NEXT INSTR position The next instruction which will be executed is displayed on the Data display. PROG CNTR position The current value of the program counter is displayed on the Data Display. (The program counter points to the location of the next instruction to be executed, since the program counter is incremented each time a new instruction is executed.) REGISTERS 0 through 3 position The contents of the 4 registers are displayed individually on the Data Display according to which register is selected.

(Continued)

Device	Use
Display Selector switch (Continued)	BREAKPOINT position The current value of the hardware breakpoint (the hardware is on the CPSI1 board) is displayed on the Data Display. A breakpoint may be set at any location in memory. When this location is accessed by an operating program, the program halts after executing the instruction in which the accessing takes place. This accessing can be the program counter being made equal to the value of the breakpoint location or an instruction accessing this location to obtain its data for execution. When the breakpoint is encountered, the breakpoint flag sets and remains set until the operator forces the program to continue. See the "Breakpoint" section, page 4.
Breakpoint switch Write Only	Depressing this switch causes a breakpoint to be detected only when that selected memory location is being written to (data is being stored into the location).
Auxiliary switch	Depressing this switch causes the program to continue running after it has detected a breakpoint, but produces a pulse on turret post C each time a breakpoint is detected.
Initialize switch	Depressing this switch causes the system to come to a predetermined set of conditions. These conditions are forced when the Control is first turned on, before any operations are performed. The Control forces these conditions on a power-up barring any malfunctions in this circuitry. The Control must also be initialized after it halts in such a way that it will not run again. The conditions after initialization are listed in the following table. CPNL Off XXXX Mem Data XXXX Mem Adrs 0000 Stack 0000 (Complete stack is cleared) RALU Flags 0001 Next Instruction (N. I.) 21FD Program Counter (P. C.) FFFE R3 0000 R2 0000 R1 0000 R0 0000 Breakpoint (B. P.) Whatever it was last set to (FFFF after power up)
Halt switch	Causes the system to halt. It may be restarted by depressing the Run switch. The light turns on anytime the Control is halted. It flickers while the Control is running and the access panel is on, but it is off when the Control is operating with the access panel turned off.
Run switch	Causes the Control to start executing instructions. The Control will execute the instruction found at the current value of the program counter, increment the program counter, execute the instruction found there, increment the program counter again and so on. The light is on when the Control is running; it is off when the Control halts.

ASR INTERFACE

The ASR interface is located on the CPSI1 board. This circuit may be disabled by connecting a jumper from A09-1 to A09-14. All connections for the ASR Interface are made through the middle plug (MPL) located on the Control. Tables showing connections between this plug and a TermiNet keyboard-printer or teletype or data set are given on the following page.

The following tables define cables for connecting Input/Output equipment to the 1050 Control. Terminal numbers are taken from the best available information; however, they are not necessarily correct for all units. If the manual pertaining to the particular equipment is available, it should be used for determining the proper connections. The 1-foot cable supplied with the Computer Access Panel is used only with a TermiNet printer. See the note in Table 4 below.

Table 3.
CONTROL INPUT/OUTPUT CONNECTOR/CPSI1

CONTROL CONNECTOR PIN	CPSI1A CONNECTOR PIN	CIRCUIT	SIGNAL NAME
1	M17	AA	0V
2	M05	BA	*TD
3	M07	BB	RD
4	M06	CA	*RTS
5	M08	CB	CTS
6	M09	CC	DSR
7	M18	AB	SIGGND
8**	M16	CF	CO
20	M04	CD	*DTR
11	M02	-	REC. DATA
14	M01	-	REC. RTRN
16	M10	-	XMTDDATA
25	M11	-	XMTDRTRN
18	M03	-	DEVUNAVAIL

* Outputs from 1050 Control.
** Wired only as an option. Normally pin 8 is open, and M13 (DTR) is connected to M16.

Table 4.
CONTROL/TERMINET †

CONTROL CONNECTOR PIN	TERMINET		
	CONNECTOR PIN	CIRCUIT	SIGNAL NAME
1	1	AA	0V
3	2	BA	††TD
2	3	BB	RD
5	4	CA	††RTS
4	5	CB	CTS
20	6	--	--
7	7	AB	SIG. GND
8	8	--	--
6	20	CD	††DTR

†Connect the 1-foot cable (3N8100CA107A1) with the Computer Access Panel to the standard cable supplied with a TermiNet printer.
††Outputs from TermiNet.

Table 5.
CONTROL/TELETYPE (MODEL 33)

CONTROL CONNECTOR PIN	TTY MODEL 33	
	TERM. BOARD	SIGNAL NAME
1	GND LUG	PROTECT GND
11	TB-3	XMTD RTRN
14	TB-4	XMTD DATA
16	TB-7	REC. DATA
25	TB-6	REC. RTRN
18	TB-5	DEV. UNAVAIL
7	] JUMPER	
4		

Table 6.
CONTROL/TELETYPE (MODEL 35)

CONTROL CONNECTOR PIN	TTY MODEL 35	
	TERM. BOARD	SIGNAL NAME
1	GND. LUB	PROTECT GND
11	TB-6	XMTD RTRN
14	TB-5	XMTD DATA
16	TB-7	REC. DATA
25	TB-8	RD RTRN
18	TB-3	DEV.
	TB-4	UNAVAIL
7	] JUMPER	
4		

Table 7.
CONTROL/DATA SET

CONTROL CONNECTOR PIN	TDM115B13 (DATASET)		
	CONN. PIN	CIRCUIT	SIGNAL NAME
1	1	AA	OV
3	3	BB	*RD
2	2	BA	TD
6	6	CC	*DSR
20	-	-	-
4	-	-	-
7	7	AB	SIG. GND.
8	8	CF	*DCD
5	5	CB	*CTS

*Outputs from dataset.

Table 8.
CONTROL/FACIT-ADD0

CONTROL CONNECTOR PIN	INTERFACE (PUNCH)		
	CONN. PIN	CIRCUIT	SIGNAL NAME
1	1	AA	OV
3	2	BA	NOT USED
2	3	BB	RD
5	12	CA	DTR
4	5	CB	NOT USED
20	6	CC	NOT USED
7	7	AB	SIG. GND.
8	8	-	-
6	12	CD	*DTR

*Outputs from punch.

This ASR interface has a programmable baud rate counter which allows you to select 6 different baud rates per the following table. This rate can be programmed by the output command used in the software.

Table 9.
PROGRAMMABLE BAUD RATE (ELEMENTARY SHEET NO. 4)

BAUD RATE	CPS	SER7 (S2)	SER6 (S1)	NECESSARY JUMPER
110*	10	0	0	
150	15	0	1	A09-2 to A09-13
300	30	0	1	
600	60	1	0	
1200	120	1	1	
2400	240	1	1	A09-3 to A09-12

*For the 110-baud rate, 1 start bit is generated for each word, followed by data bits, parity bit (if used) and 2 stop bits. For all other baud rates in this system, there is only 1 stop bit per word.

The output command, sense status, and data bits for the ASR interface are listed below and on page 13. A description of the function of the bit at logic 1 or logic 0 is given below each bit.

Output Command Byte

Register 0 Bit							
7	6	5	4	3	2	1	0
S2	S1	Even Parity	Enable Parity	Unblock	Enable Int.	Read	Write
Baud rate selection. See Table 8, page 11.	Baud rate selection. See Table 8, page 11.	1- Even Parity 0- Odd Parity Generated by the transmitter and checked by the receiver.	1- Enables parity generation and verification circuits. Word length: 1 start bit, 7 bits data, 1 bit parity, 1 stop bit. 0- Inhibits parity generation and verification circuits. Clamps parity error (PE) output to 0. Word length: 1 start bit, 8 bits data, 1 stop bit.	(Significant only in the Read mode). 1- Causes data to be echoed back to the printer. 0- Prevents data from being echoed back to the Printer.	1- Permits an interrupt. 0- Clears any pending interrupt and prevents additional interrupts.	1- Permits data input from the keyboard-printer to the processor. 0- Prevents data input to the processor.	1- Permits data output from the processor to the keyboard printer. 0- Prevents data output.

Sense Status Command Byte

Register 0 Bit							
7 CTSON (Clear to Send On)	6 TRNE (Transmit Register Not Empty)	5 PE (Parity Error)	4 OE (Overrun Error)	3 FE (Framing Error)	2 DU (Device Unable)	1 BUSY	0 ERR (Error)
1- When the Clear to Send signal is being received from a device.	1- In the Write mode, indicates that the data transmitting register has not been emptied by serial transmission of the entire character. In the Read mode, TRNE is 0.	1- In the Read mode, indicates that there is a parity error in the received character.	1- In the Read mode, indicates that the Data Received Flag was not reset before the next character was transferred to the receive holding register. 1- In the Write mode, indicates that a key has been depressed 2 or more times.	1- In the Read mode, indicates that the received character has no valid stop bit. 1- In the Write mode, indicates that the Break key has been depressed.	1- Indicates that the device is unavailable.	1- In the Write mode, indicates that the transmit data holding buffer is full. 1- In the Read mode, indicates that the receive data register is empty. In other words, the entire character has been received and transferred to the receive data holding register.	1- Indicates a parity error, overrun error, or framing error.

Note: An error condition can be cleared by an output command with a command byte of any value.

Write Byte or Read Byte

Register 0 Bit							
7 DATA Bit 8	6 DATA Bit 7	5 DATA Bit 6	4 DATA Bit 5	3 DATA Bit 4	2 DATA Bit 3	1 DATA Bit 2	0 DATA Bit 1

DATA IN/OUT AND OFF-LINE CAPABILITY

The access panel has the ability of responding to 1 of 2 different addresses. The address it normally responds to in the system (its on-line address), and the address it responds to with the off-line jumper in. All addresses related to the panel are given below.

DEVICE	BASE ADDRESS	NECESSARY JUMPERS*
Access Panel On-Line	00E0	
Access Panel Off-Line	00C0	J13-1 to J13-2
ASR	00F0	**

The "off-line" address capability facilitates testing of the panel by programming it as a separate entity, not as a reporting device of the state of the system.

When on line, the panel communicates with the system through a program in PROMS on the Central Processing Unit. This program reports the status of the system to the panel and allows the panel to interrupt the operation of the system in order to input data and control information from the operator devices on the panel to the system.

The Sense Status bits for the panel are as follows:

Sense Status
Register 0 Bits

7	6	5	4	3	2	1	0
				$\overline{\text{CPNLINT}}$	BRKPNT	ILLEG	$\overline{\text{FIRST}}$

$\overline{\text{FIRST}}$ (Bit 0)	0- After hardware clear. 1- After first output command; remains a 1 until a hardware clear is initiated.
ILLEG (Bit 1)	1- If more than approximately 150 milliseconds elapses between control panel sense statuses when the panel is not turned off. 0- When the panel is off or sensed at least once per 150 milliseconds.
BRKPNT (Bit 2)	1- When a breakpoint is detected. Once set, it stays set until the breakpoint match is cleared. 0- When the breakpoint is not detected.
$\overline{\text{CPNLINT}}$ (Bit 3)	0- When the access panel interrupts the Control from executing a program in order to service the access panel or when the Control is halted from executing a program, at which time it continually services the panel. 1- When the Control is executing a program.

By writing to the access panel with BWC Bit 5 set, the data written is held in the synchronizing latches.

It may then be verified by reading with BWC Bit 5 reset.

Data read with BWC 5 Bit set is data from the access panel (switches).

Read data bits are as follows:

* Refer to Table 1, page 2 for a complete list and description of jumpers for operation of the panel and ASR in either mode.

** ASR may be disabled completely with addition of ASR-OFF jumper (A09-1 to A09-14).

READ DATA

BWC BITS	REGISTER 0	BITS
543210	7 6	5 4 3 2 1 0
1XXX00		Byte 0
1XXX01		Byte 1
1XXX10		Byte 2
1XXX11		Byte 3

Byte 0 - Data switches 0-7 (Data switch 0 corresponds to RO Bit 0.)

Byte 1 - Data switches 8-15 (Data switch 8 corresponds to R0 Bit 0.)

Byte 2 - Selector switch positions CONTROL PANEL OFF thru REGISTER 3 going clockwise (CONTROL PANEL OFF corresponds to REGISTER 0 Bit 0)

Byte 3 - Selector position REGISTER 2 thru BREAKPOINT continuing clockwise, Initialize Signal, Increment Memory switch, Load Data switch, and the "PSERV" Signal (Register 2 corresponds to Register 0 Bit 0)

The Initialize signal comes with the depression of either the Initialize switch or the Load Tape switch.

The PSERV signal comes with the depression of any of the following switches: Initialize, Load Tape, Increment Memory Address, Load Data, Run, and Single Instruction.

Writing data to the access panel with BWC Bit 5 set puts the data written on the program counter and data displays of the panel as per the table and illustration below:

WRITE DATA

BWC BITS	REGISTER 0	BITS
5 4 3 2 1 0	7 6 5	4 3 2 1 0
1 X X X 0 0		Byte 0
1 X X X 0 1		Byte 1
1 X X X 1 0		Byte 2
1 X X X 1 1		Byte 3

PROGRAM COUNTER DISPLAY

BYTE 1	BYTE 0

DATA DISPLAY

BYTE 3	BYTE 2

APPLIED PRACTICES	SURFACES	TOLERANCES ON MACHINED DIMENSIONS		
		FRACTIONS	DECIMALS	ANGLES
	✓	±	±	±

COMPUTER ACCESS PANEL
FIRST MADE FOR 1050
INDEX SHEET

CONTAINED WITHIN ARE THE ELEMENTARY DIAGRAMS FOR THE CPSIIA AND OCPI BOARDS, INTERCONNECTION DIAGRAMS FOR THE COMPUTER ACCESS PANEL, AND A SIMPLIFIED BLOCK DIAGRAM FOR THE CPSII DATA PATH. ADDITIONAL INFORMATION MAY BE FOUND IN THE COMPUTER ACCESS PANEL INSTRUCTION BOOK (GEK-45668).

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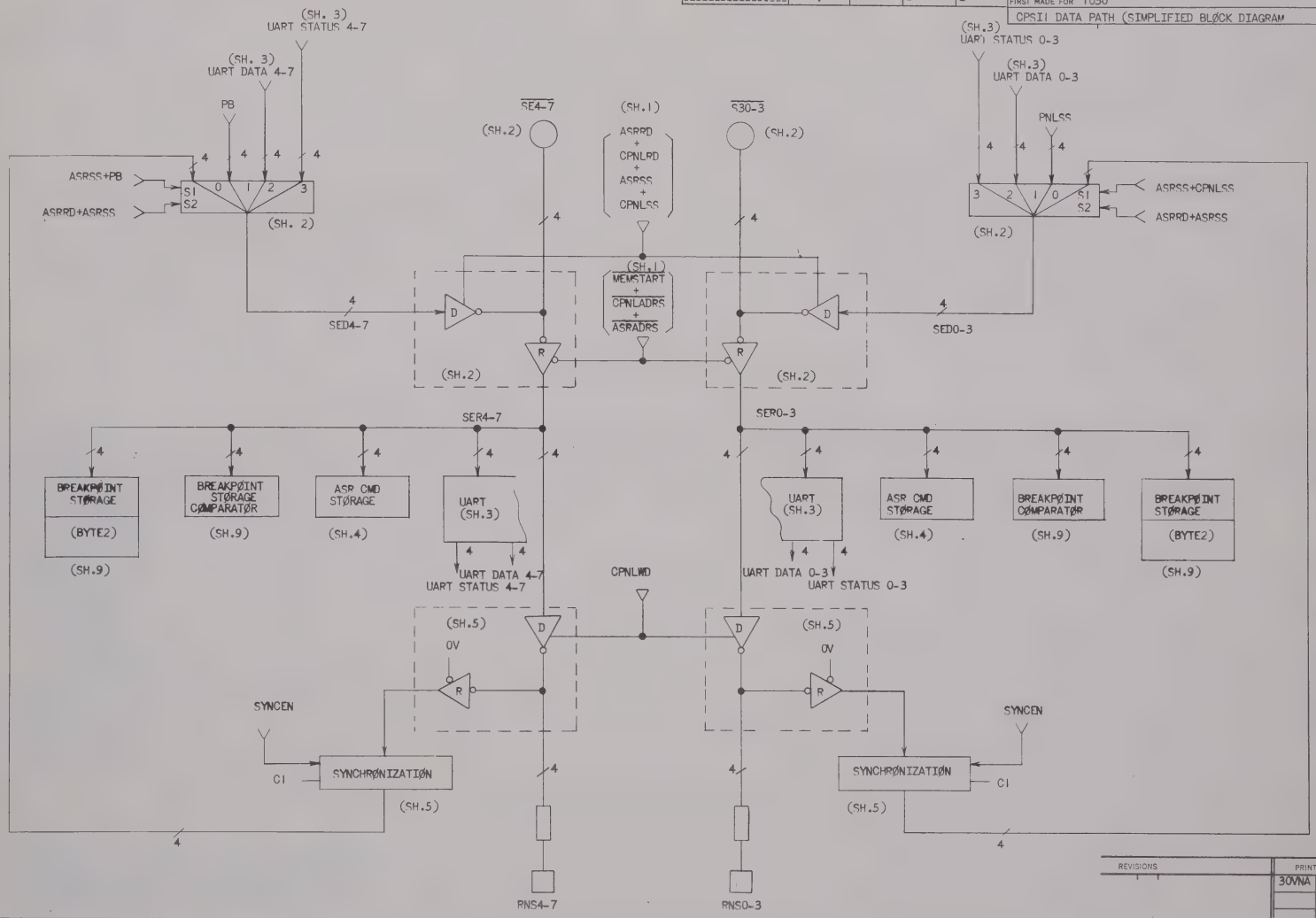
COMPUTER ACCESS PANEL
FIRST MADE FOR 1050
CPSII DATA PATH (SIMPLIFIED BLOCK DIAGRAM



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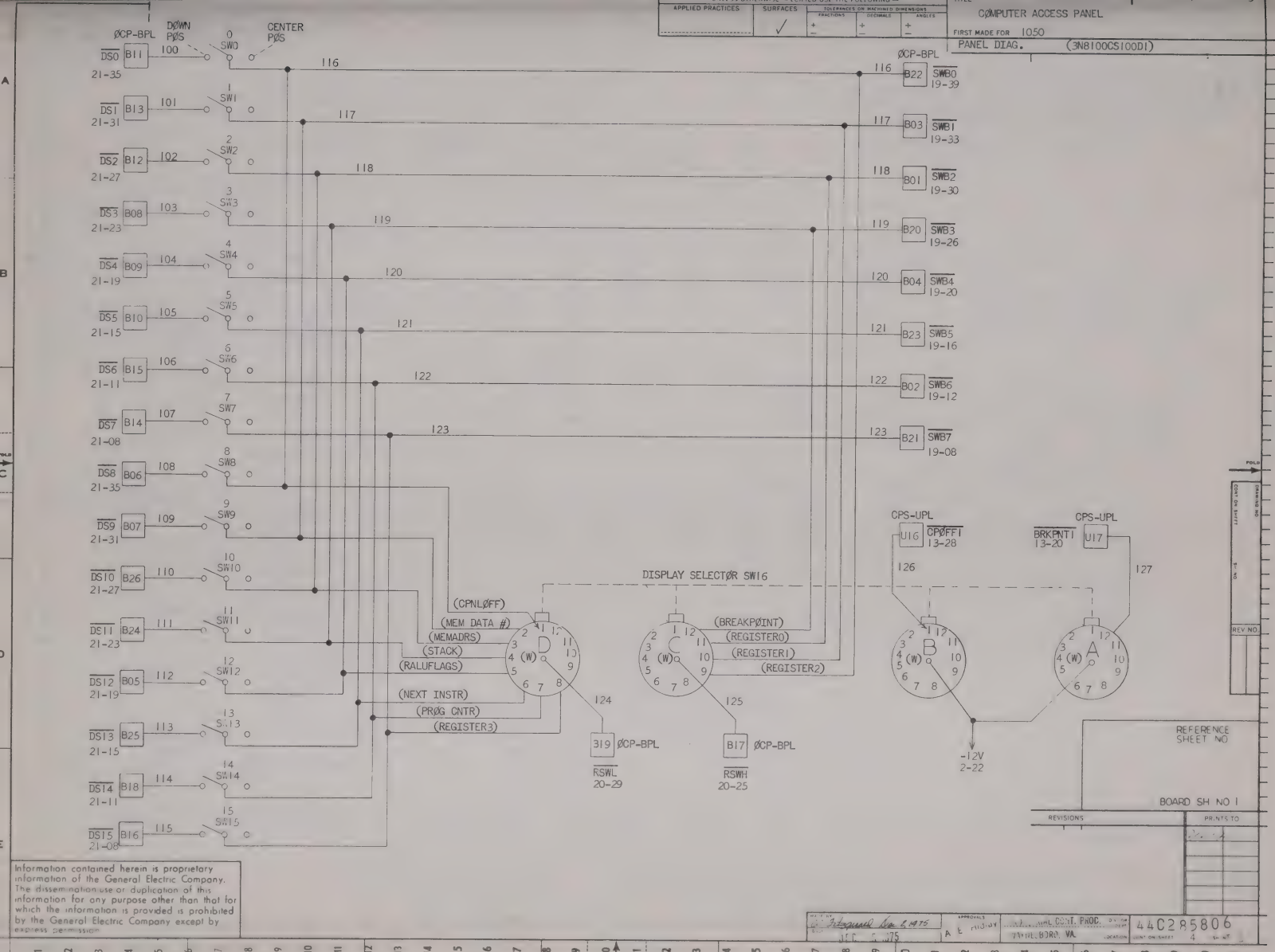
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FRACTIONS
DECIMALS
ANGLES
COMPUTER ACCESS PANEL
FIRST MADE FOR 1050
PANEL DIAG. (3N8100CS100D1)
ØCP-BPL
DOWN PØS
CENTER PØS
DS0 B11 100 SW0 116
DS1 B13 101 SW1 117
DS2 B12 102 SW2 118
DS3 B08 103 SW3 119
DS4 B09 104 SW4 120
DS5 B10 105 SW5 121
DS6 B15 106 SW6 122
DS7 B14 107 SW7 123
DS8 B06 108 SW8
DS9 B07 109 SW9
DS10 B26 110 SW10
DS11 B24 111 SW11
DS12 B05 112 SW12
DS13 B25 113 SW13
DS14 B18 114 SW14
DS15 B16 115 SW15
21-35
21-31
21-27
21-23
21-19
21-15
21-11
21-08
21-35
21-31
21-27
21-23
21-19
21-15
21-11
21-08
ØCP-BPL
B22 SWB0 19-39
B03 SWB1 19-33
B01 SWB2 19-30
B20 SWB3 19-26
B04 SWB4 19-20
B23 SWB5 19-16
B02 SWB6 19-12
B21 SWB7 19-08
CPS-UPL
U16 CPØFF1 13-28
BRKPNT1 13-20 U17
DISPLAY SELECTØR SW16
(CPNLØFF)
(MEM DATA #)
(MEMADRS)
(STACK)
(RALUFLAGS)
(NEXT INSTR)
(PRØG CNTR)
(REGISTER3)
(BREAKPØINT)
(REGISTER0)
(REGISTER1)
(REGISTER2)
124
125
126
127
319 ØCP-BPL RSWL 20-29
B17 ØCP-BPL RSWH 20-25
-12V 2-22
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TITLE
COMPUTER ACCESS PANEL

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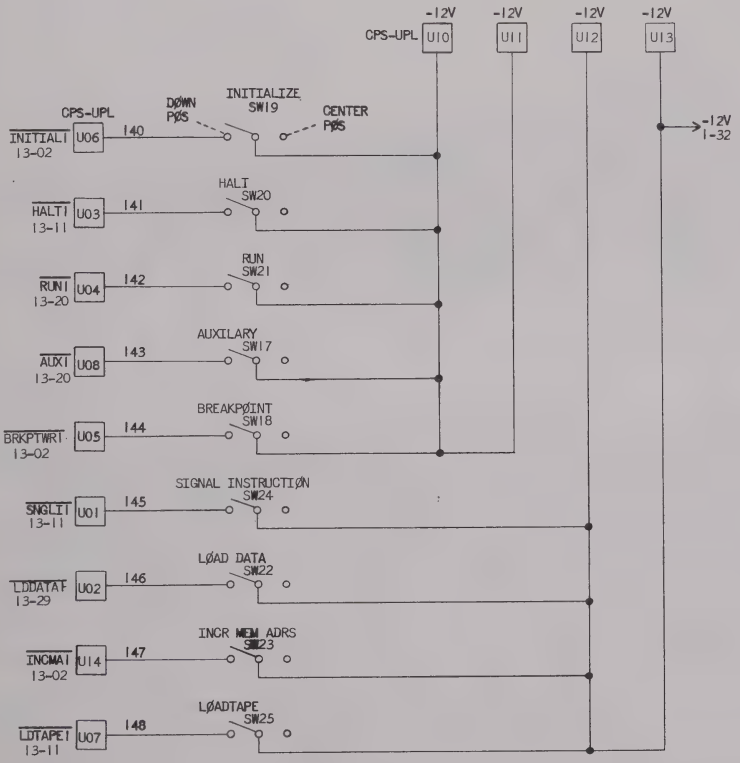
PANEL DIAG. (3N8100CS100D1)



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		FRACTIONS	DECIMALS	ANGLES
	✓	±	±	±

COMPUTER ACCESS PANEL

FIRST MADE FOR 1050

INTERFACE FØR TERMINET, TELETYPE, AND TAPE PUNCH

THE FØLLØWING TABLES DEFINE CABLES FØR CØNNECTING I/Ø EQUIPMENT TØ THE 1050 CØNTRØL. TERMINAL NUMBERS ARE TAKEN FRØM THE BEST AVAILABLE INFØRMATIØN; HØWEVER, THEY ARE NØT NECESSARILY CØRRECT FØR ALL UNITS. IF THE MANUAL PERTAINING TØ THE PARTICULAR EQUIPMENT IS AVAILABLE, IT SHØULD BE USED FØR DETERMINING THE PRØPER CØNNECTIØNS.

TERMINET CABLE FØR RS-232C INTERFACE - 3N8100CA100R1
TDM115B13 CABLE - SPECIAL
TTY CABLE - 3N8100CA100S1

STATUS AND CØMMAND BYTE

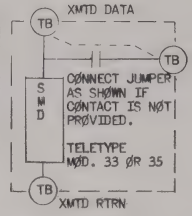
BIT NUMBER	7	6	5	4	3	2	1	0
STATUS BYTE	CLEAR TØ SEND	TRANSMIT REGISTER NØT EMPTY	PARITY ERRØR	ØVERRUN ERRØR	FRAMING ERRØR	DEVICE UN-AVAILABLE	BUSY	ERRØR
CØMMAND BYTE	S2	S1	EVEN PARITY	ENABLE PARITY	UNBLØCK	ENABLE INTERRUPT	READ	WRITE

CPSIIA FUNCTIØN	WIRE WRAP CØNNECTIØNS- FRØM	TØ	FRØM	TØ	FRØM	TØ	FRØM	TØ
SCØPE SYNC. BAUD RATE	A03-3 A09-4	A03-5 A09-11	A09-11	A09-9	A09-5	A09-10	A09-6	A09-7
TIMER RERSHREQ	M02-1 M02-3	M02-8 M02-6	M02-2	M02-7				
UNBLØCK*	L11A	L11B						

*(UNB) UNBLØCK WITH JUMPER REMØVED. THE TERMINAL CØNNECTED TØ THE CPSII SERIAL PØRT CAN BE CHECKED BY ECHØ PLEX ØPERATIØN ØF THE TERMINAL.

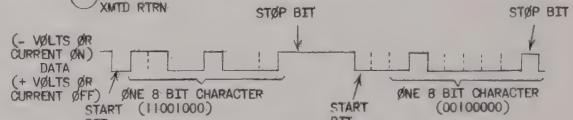
CØMMAND BIT7	CØMMAND BIT6	BAUD RATE	CPSIIA JUMPER A09-2 TØ A09-13	CPSIIA JUMPER A09-3 TØ A09-12	NØ. STØP BITS
0	0	110	NA	NA	2
0	0	150	IN	NA	1
0	1	300	ØUT	NA	1
1	0	600	NA	NA	1
1	1	1200	NA	ØUT	1
1	1	2400	NA	IN	1

CHAR/SEC	UAR/T NØMINAL	UAR/T CLK ACTUAL	% ERRØR
10	1760	1736	-1.36
15	2400	2404	+.167
30	4800	4808	+.167
60	9600	9616	+.167
120	19200	19231	-.161
240	38400	37878	-.136



CURRENT INTERFACE

DATA LINE:
CURRENT ØN WHEN NØ DATA IS BEING TRANSMITTED.
DEVICE UNAVAILABLE LINE:
ØPEN CØNTACT WHEN DEVICE IS UNAVAILABLE.
+3.0 VØLTS (MIN) WHEN DEVICE IS AVAILABLE.



FACIT-ADDØ MØDEL 4070

I/Ø CØNNECTØR

CØNTRØL CØNNECTØR PIN	CPSIIA CØNNECTØR PIN	CIRCUIT	SIGNAL NAME
1		AA	GND STUD
	M12	SHIELD	0V
2	M05	BA	*TD
3	M07	BB	RD
20	M06	CA	*RTS
5	M08	CB	CTS
6	M09	CC	DSR
7	M18	AB	SIGGND
8**	M16	CF	CØ
4	M04	CD	*DTR
11	M02		REC.DATA
14	M01		REC.RTRN
16	M10		XMTDDATA
25	M11		XMTDRTRN
18	M03		DEVUNAVAIL

* ØUTPUTS FRØM 1050 CØNTRØL
**WIRED ØNLY AS AN ØPTIØN.
PIN 8 IS ØPEN AND M13 CØNNECTED TØ M16 FØR TERMINET, TTY 33, TTY 35 AND PUNCH.

NØTE THAT STANDARD TERMINET CABLE USED WITH DATA SET ØR ACØUSTIC CØUPLER IS NØT CØMPATIBLE FØR THIS APPLICATIØN. THREE WIRE PAIRS ARE ØPPØSITE FRØM THØSE SHØWN IN TERMINET TABLE. THESE PAIRS ARE 3 AND 2, 5 AND 4, AND 20 AND 6.

CØNTRØL CØNNECTØR PIN	TERMINET CØNN PIN	CIRCUIT	SIGNAL NAME
1	1	AA	0V
3	2	BA	*TD
2	3	BB	RD
5	4	CA	*RTS
4	5	CB	CTS
20	6		
7	7	AB	SIG.GND
8	8		
6	20	CD	*DTR

*ØUTPUTS FRØM TERMINET

CØNTRØL CØNNECTØR PIN	TDM115B13 (DATASET) CØNN. PIN	CIRCUIT	SIGNAL NAME
1	1	AA	0V
3	3	BB	*RD
2	2	BA	TD
6	6	CC	*DSR
20			
4			
7	7	AB	SIG.GND
**8	8	CF	*DCD
5	5	CB	*CTS

*ØUTPUTS FRØM DATASET
**REMØVE JUMPER M13 AND M16 AND ADD WIRE FRØM CØNTRØL CØNNECTØR PIN 8 TØ CPSII CØNNECTØR PIN M08.

CØNTRØL CØNNECTØR PIN	INTERFACE (PUNCH) CØNN. PIN	CIRCUIT	SIGNAL NAME
1	1	AA	0V
3	2	BA	NØT USED
2	3	BB	RD
5	12	CA	DTR
4	5	CB	NØT USED
20	6	CC	NØT USED
7	7	AB	SIG.GND
8	8		
6	12	CD	*DTR

*ØUTPUTS FRØM PUNCH

CØNTRØL CØNNECTØR PIN	TTY MØDEL 33 TERM. BØARD	SIGNAL NAME	WIRE CØLØR
1	GND LUG	PRØTECT GND	BRØWN
11	TB-3	XMTD RTRN	GREEN
14	TB-4	XMTD DATA	BLUE
16	TB-7	REC. DATA	RED
25	TB-6	REC. RTRN	WHITE
18	TB-5	DEV.UNAVAIL	YELLØW
7	┐ JUMPER		
4	┘		

THE INTERFACE CIRCUIT IS DESIGNED FØR 20 MA CURRENT LØØP.

CØNTRØL CØNNECTØR PINS	TTY MØDEL 35 TERM. BØARD	SIGNAL NAME	WIRE CØLØR
1	GND LUG	PRØTECT GND	BRØWN
11	TB-6	XMTD RTRN	GREEN
14	TB-5	XMTD DATA	BLUE
16	TB-7	REC. DATA	RED
25	TB-8	RD RTRN	WHITE
18	TB-3	DEV. UNAVAIL	YELLØW
7	TB-4 ┐ JUMPER		
4	┘		

THE INTERFACE CIRCUIT IS DESIGNED FØR 20 MA CURRENT LØØP.

NØTE: CØLØR CØDE SHØWN IN TTY CABLE CØNNECTIØNS IN TABLES ABØVE REFER TØ WIRE CØLØRS IN G.E. SUPPLIED CABLE (3N8100CA1005)

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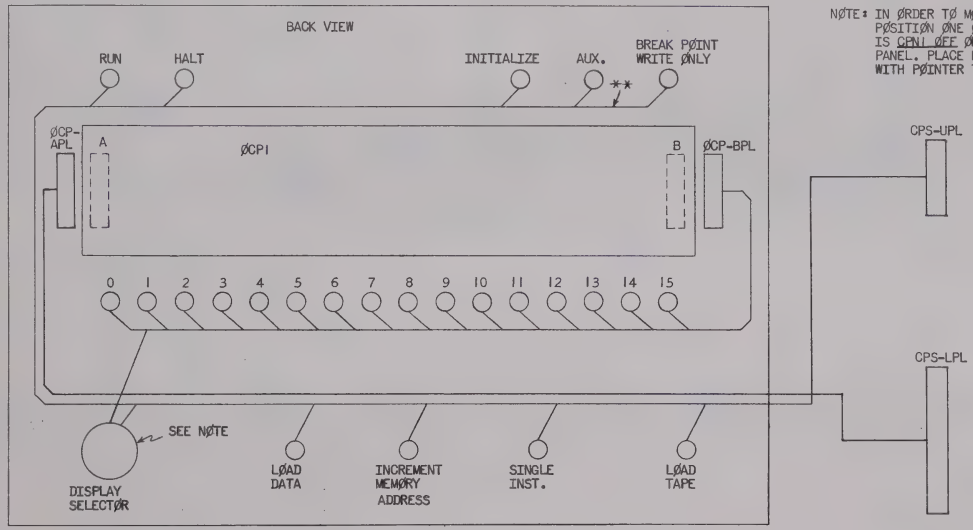
APPLIED PRACTICES	SURFACES	TOLERANCES ON MACHINED DIMENSIONS FRACTIONS	DECIMALS	ANGLES
	✓	±	±	±

TITLE
CØMPUTER ACCESS PANEL

FIRST MADE FOR 1050

CØNN. DIAG. (3N8100CS100D1)

CPU CØNTRØL STATIØN



NØTE: IN ØRDER TØ MØUNT THE KNØB FIND PØSITIØN ØNE ØN THE SWITCH. THIS IS CØNI ØFF ØN FRØNT ØF THE PANEL. PLACE KNØB ØN THE SWITCH WITH PØINTER TØ CØNI ØFF.

WIRE TABLE FØR CPS-UPL

	PIN	CKT. NØ.	WIRE SIZE AND CØLØR	CØNNECT TØ
	1	145	24 WHITE	SW24
	2	146	24 WHITE	SW22
	3	141	24 WHITE	SW20
	4	142	24 WHITE	SW21
	5	144	24 WHITE	SW18
	6	140	24 WHITE	SW19
	7	148	24 WHITE	SW25
	8	143	24 WHITE	SW17
	9			
	10	-12V	24 WHITE	SW21
	11	-12V	24 WHITE	SW18
	12	-12V	24 WHITE	SW16-A-W
	13	-12V	24 WHITE	SW25
	14	147	24 WHITE	SW23
*	15	SPARE	24 WHITE	SPARE IFI
	16	126	24 WHITE	SW16-B-1
	17	127	24 WHITE	SW16-A-12
	18			

24 WHITE WIRE MUST BE STRANDED

* RUN WIRE IN BUNDLE BUT CØNNECT ØNLY ØNE END TØ PIN 15 ØN CPS-UPL

** END ØF SPARE WIRE

WIRE TABLE FØR PANEL

CKT. NØ.	WIRE SIZE AND CØLØR	SEQUENCE ØF CØNN.
116	24 WHITE	SW16-C-9,SW16-D-1,SW0,SW8
117	24 WHITE	SW16-C-10,SW16-D-2,SW1,SW9
118	24 WHITE	SW16-C-11,SW16-D-3,SW2,SW10
119	24 WHITE	SW16-C-12,SW16-D-4,SW3,SW11
120	24 WHITE	SW16-D-5,SW4,SW12
121	24 WHITE	SW16-D-6,SW5,SW13
122	24 WHITE	SW16-D-7,SW6,SW14
123	24 WHITE	SW16-D-8,SW7,SW15
-12V	24 WHITE	SW21,SW20,SW19,SW17,SW18
-12V	24 WHITE	SW16-A-W,SW16-B-W,SW22,SW23,SW24 SW25

#24 WHITE MUST BE STRANDED

WIRE TABLE FØR ØCP-BPL

PIN NØ.	CKT. NØ.	WIRE SIZE AND CØLØR	CØNNECT TØ
1	118	24 WHITE	SW10
2	122	24 WHITE	SW14
3	117	24 WHITE	SW9
4	120	24 WHITE	SW12
5	112	24 WHITE	SW12
6	108	24 WHITE	SW8
7	109	24 WHITE	SW9
8	103	24 WHITE	SW3
9	104	24 WHITE	SW4
10	105	24 WHITE	SW5
11	100	24 WHITE	SW0
12	102	24 WHITE	SW2
13	101	24 WHITE	SW1
14	107	24 WHITE	SW7
15	106	24 WHITE	SW6
16	115	24 WHITE	SW15
17	125	24 WHITE	SW16-C-W
18	114	24 WHITE	SW14
19	124	24 WHITE	SW16-D-W
20	119	24 WHITE	SW11
21	123	24 WHITE	SW15
22	116	24 WHITE	SW8
23	121	24 WHITE	SW13
24	111	24 WHITE	SW11
25	113	24 WHITE	SW13
26	110	24 WHITE	SW10
PINS 27-38 ARE NØT USED			

24 WHITE WIRE MUST BE STRANDED

REFERENCE SHEET NO.

BOARD SH. NO. 1

REVISIONS | PRINTS TO

304 MM

REV NO.

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MADE BY W. Hayward Dec. 6 1965 | APPROVALS R. Hidlay | INDUSTRIAL CONT. PROD. | DIV. OR DEPT. | 44C285806

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COMPUTER ACCESS PANEL

FIRST MADE FOR 1050

CONN. JIAG (3N8100CS100D1)

BACK VIEW

RUN 142 -12V SW21

HALT 141 -12V SW20

INITALIZE 140 -12V SW19

AUX 143 -12V SW17

BREAKPOINT 144 -12V SW18

38 (UPPER = PIN 19, LOWER = PIN 38)

20 (UPPER = PIN 1, LOWER = PIN 20)

A

B

ØCP1

(PRINTED CIRCUIT BOARD)

0 100 116 SW0 117

1 101 SW1

2 102 118 SW2

3 103 119 SW3

4 104 120 SW4

5 105 121 SW5

6 106 122 SW6

7 107 123 SW7

8 108 116 SW8

9 109 117 SW9

10 110 118 SW10

11 111 119 SW11

12 112 120 SW12

13 113 121 SW13

14 114 122 SW14

15 115 123 SW15

DISPLAY SELECTØR SW16

LØAD DATA 146 -12V SW22

INCMEMADD 147 -12V SW23

SINGLE INSTRUCTIØN 145 -12V SW24

LØAD TAPE 148 -12V SW25

D: 116, 124, 117, 118, 119, 120, 121, 122, 123

C: 125, 119, 118, 117, 116

B: 126, -12V

A: -12V, 127

D C B A

REFERENCE SHEET NO.

BOARD SH. NO. 2

REVISIONS

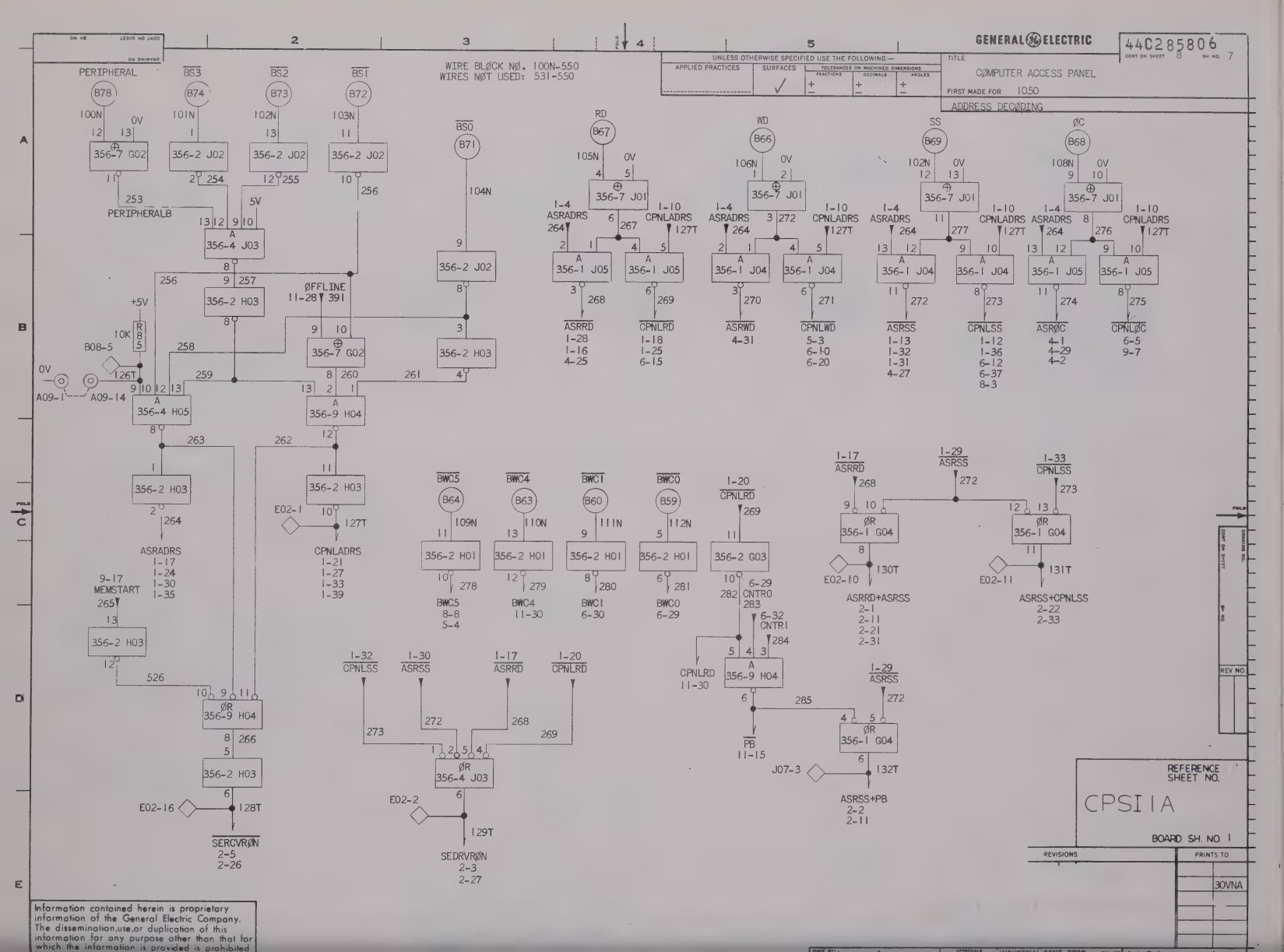
PRINTS TO

MADE BY R. Hayward DEC 3 1975

APPROVALS A. E. Hidlay

INDUSTRIAL CONT. PROD. WAYNESBORO, VA.

44C285806


GENERAL ELECTRIC
44C285806
CONT ON SHEET 8 SH NO. 7
UNLESS OTHERWISE SPECIFIED USE THE FOLLOWING:—
APPLIED PRACTICES
SURFACES
TOLERANCES ON MACHINED DIMENSIONS
FRACTIONS
DECIMALS
ANGLES
TITLE
COMPUTER ACCESS PANEL
FIRST MADE FOR 1050
ADDRESS DECODING
WIRE BLOCK NO. 100N-550
WIRES NOT USED: 531-550
PERIPHERAL
B78
B74
B73
B72
B71
B67
B66
B69
B68
B64
B63
B60
B59
356-7 G02
356-2 J02
356-4 J03
356-2 H03
356-7 J01
356-1 J05
356-1 J04
356-4 H05
356-9 H04
356-2 H01
356-2 G03
356-1 G04
ØR
PERIPHERALB
ØFFLINE
11-28
391
ASRADRS
1-17
1-24
1-30
1-35
CPNLADRS
1-21
1-27
1-33
1-39
MEMSTART
9-17
BWC5
8-8
5-4
BWC4
11-30
BWC1
6-30
BWC0
6-29
CPNLRD
11-30
CNTR0
6-29
CNTR1
6-32
ASRRD
1-28
1-16
4-25
CPNLRD
1-18
1-25
6-15
ASRWD
4-31
CPNLWD
5-3
6-10
6-20
ASRSS
1-13
1-32
1-31
4-27
CPNLSS
1-12
1-36
6-12
6-37
8-3
ASRØC
4-1
4-29
4-2
CPNLØC
6-5
9-7
ASRRD+ASRSS
2-1
2-11
2-21
2-31
ASRSS+CPNLSS
2-22
2-33
ASRSS+PB
2-2
2-11
SERCVRØN
2-5
2-26
SEDRVRØN
2-3
2-27
PB
11-15
REFERENCE SHEET NO.
CPSI1A
BOARD SH. NO. 1
REVISIONS
PRINTS TO
30VNA
REV NO.
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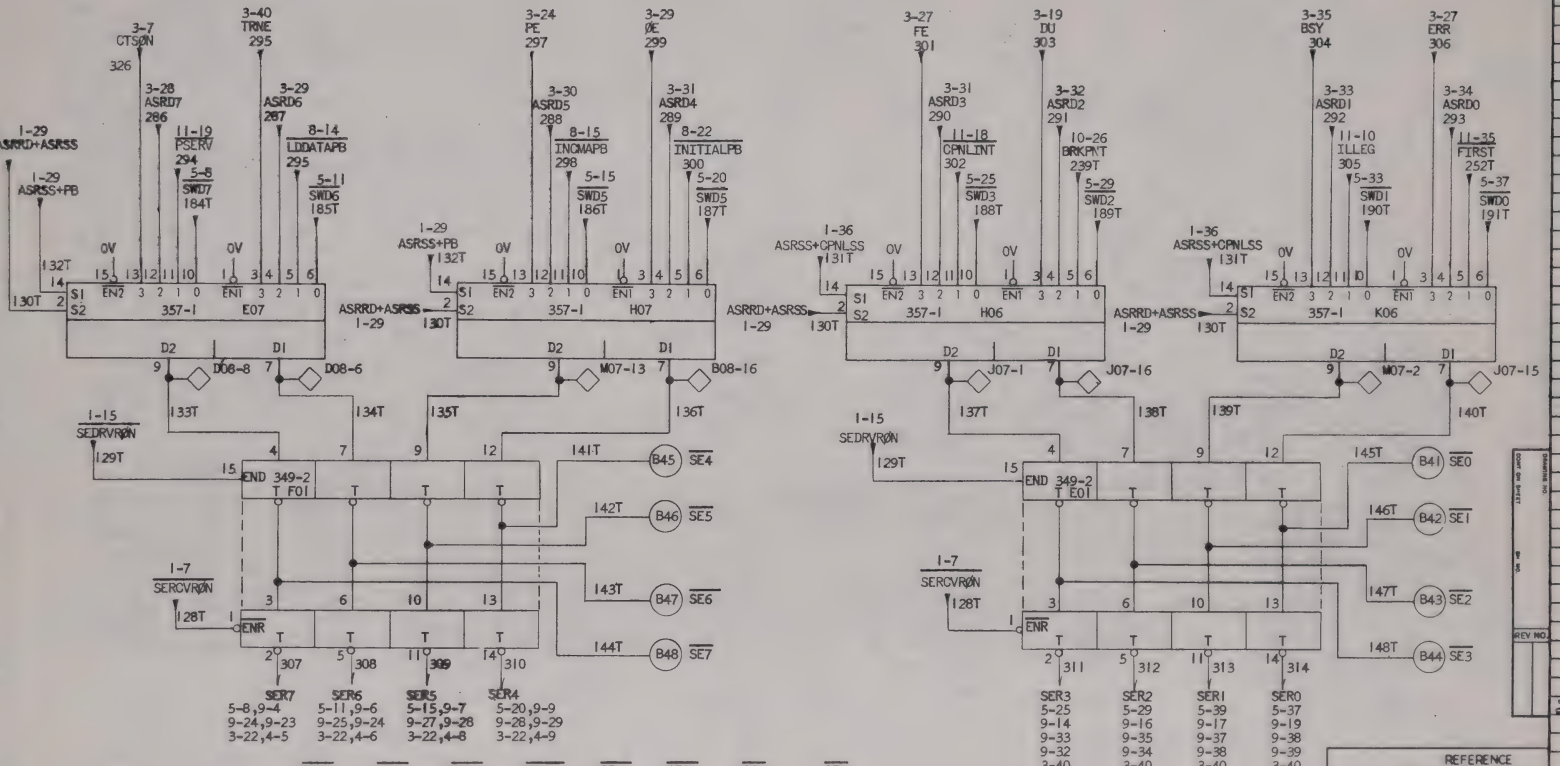
APPLIED PRACTICES	SURFACES	TOLERANCES ON MACHINED DIMENSIONS: FRACTIONS	DECIMALS	ANGLES
	✓	±	±	±

COMPUTER ACCESS PANEL

FIRST MADE FOR 1050

BACKPLANE DATA PATH



REFERENCE SHEET NO.

CPSIIA

BOARD SH. NO. 2

REVISIONS

PRINTS TO

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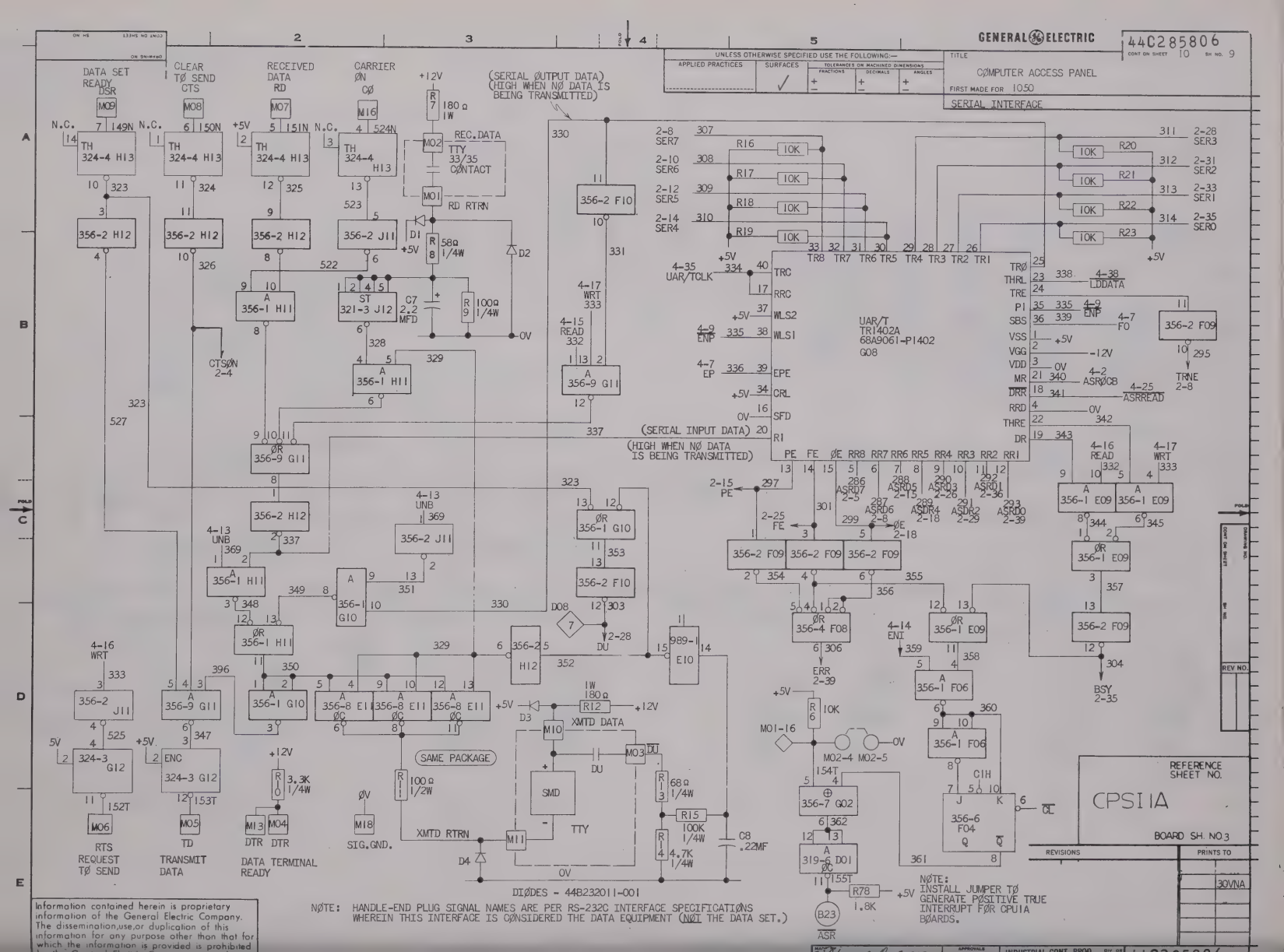
DRAWN BY	APPROVALS		
W. F. Bonner Dec 2, 1975	A. E. Hidley	INDUSTRIAL CONT. PROD.	44C285806
ISSUED DEC 5 1975		WAYNESBORO, VA.	CONT ON SHEET 9 SH NO 8


GENERAL ELECTRIC
44C285806
CONT ON SHEET 10 SH NO. 9
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APPLIED PRACTICES
SURFACES
TOLERANCES ON MACHINED DIMENSIONS
FRACTIONS
DECIMALS
ANGLES
TITLE
COMPUTER ACCESS PANEL
FIRST MADE FOR 1050
SERIAL INTERFACE
DATA SET READY DSR
CLEAR TØ SEND CTS
RECEIVED DATA RD
CARRIER ØN CØ
(SERIAL ØUTPUT DATA) (HIGH WHEN NØ DATA IS BEING TRANSMITTED)
REC. DATA
TTY 33/35 CONTACT
RD RTRN
CTSØN 2-4
(SERIAL INPUT DATA)
(HIGH WHEN NØ DATA IS BEING TRANSMITTED)
UAR/T TR1402A 68A9061-P1402 G08
TR8 TR7 TR6 TR5 TR4 TR3 TR2 TR1
PE FE ØE RR8 RR7 RR6 RR5 RR4 RR3 RR2 RR1
XMTD DATA
XMTD RTRN
SAME PACKAGE
SMD
TTY
SIG.GND.
DIØDES - 44B232011-001
NØTE: HANDLE-END PLUG SIGNAL NAMES ARE PER RS-232C INTERFACE SPECIFICATIØNS WHEREIN THIS INTERFACE IS CØNSIDERED THE DATA EQUIPMENT (NØT THE DATA SET.)
RTS REQUEST TØ SEND
TRANSMIT DATA
DTR DATA TERMINAL READY
NØTE: INSTALL JUMPER TØ GENERATE PØSITIVE TRUE INTERRUPT FØR CPUIA BØARDS.
REFERENCE SHEET NO.
CPSIIA
BOARD SH. NO 3
REVISIONS
PRINTS TO
30VNA
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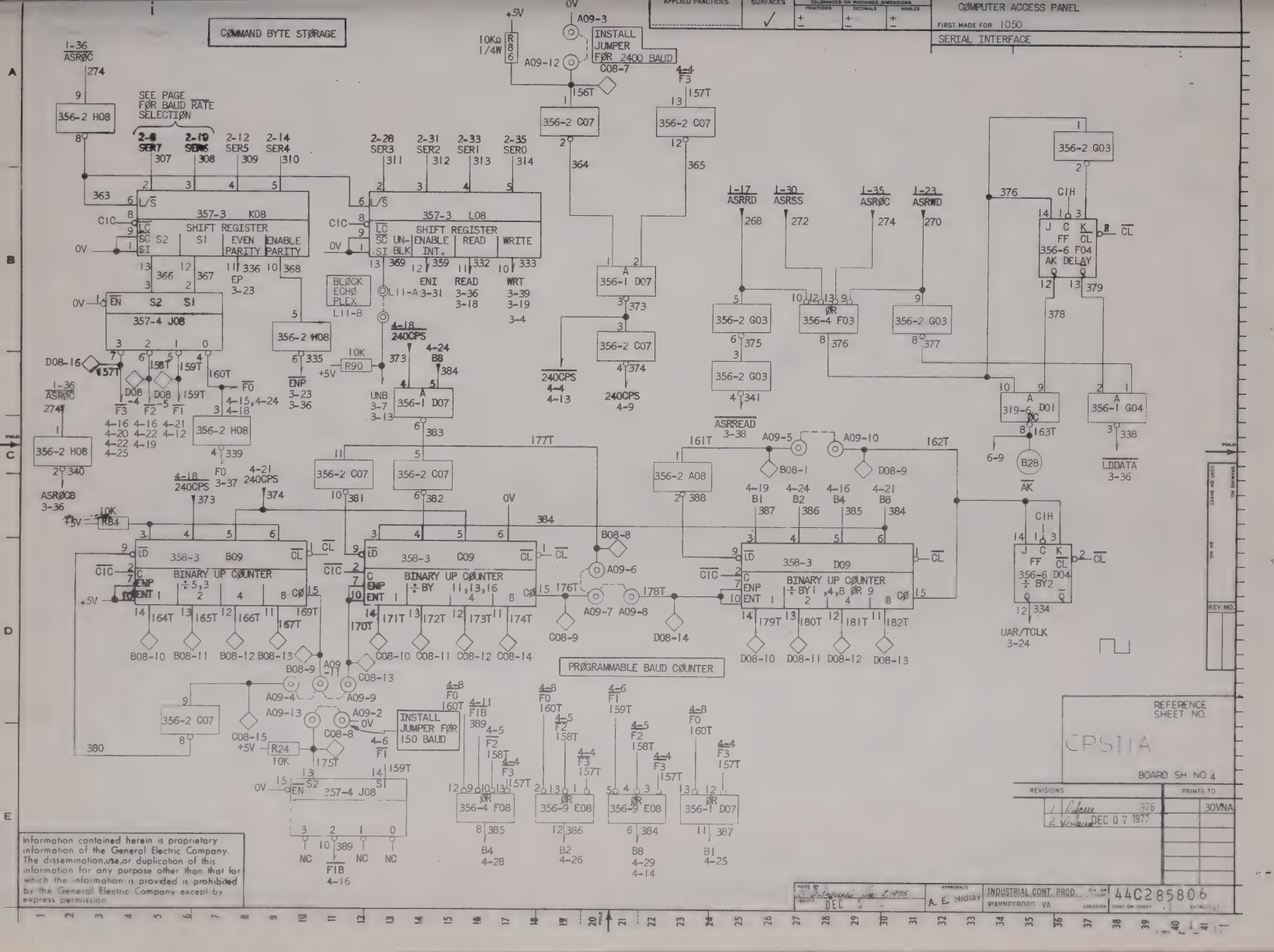
COMMAND BYTE STORAGE
COMPUTER ACCESS PANEL
FIRST MADE FOR 1050
SERIAL INTERFACE
SEE PAGE FOR BAUD RATE SELECTION
INSTALL JUMPER FOR 2400 BAUD
INSTALL JUMPER FOR 150 BAUD
PROGRAMMABLE BAUD COUNTER
SHIFT REGISTER
BINARY UP COUNTER
BLOCK ECHO PLEX
ENABLE PARITY
EVEN PARITY
UN-BLK
ENABLE INT.
READ
WRITE
ENI
WRT
UAR/TCLK 3-24
LDDATA 3-36
ASRØCB 3-36
CPSIIA
BOARD SH NO 4
REFERENCE SHEET NO.
REVISIONS
PRINTS TO
30VNA
INDUSTRIAL CONT. PROD.
WAYNESBORO VA
44C285806
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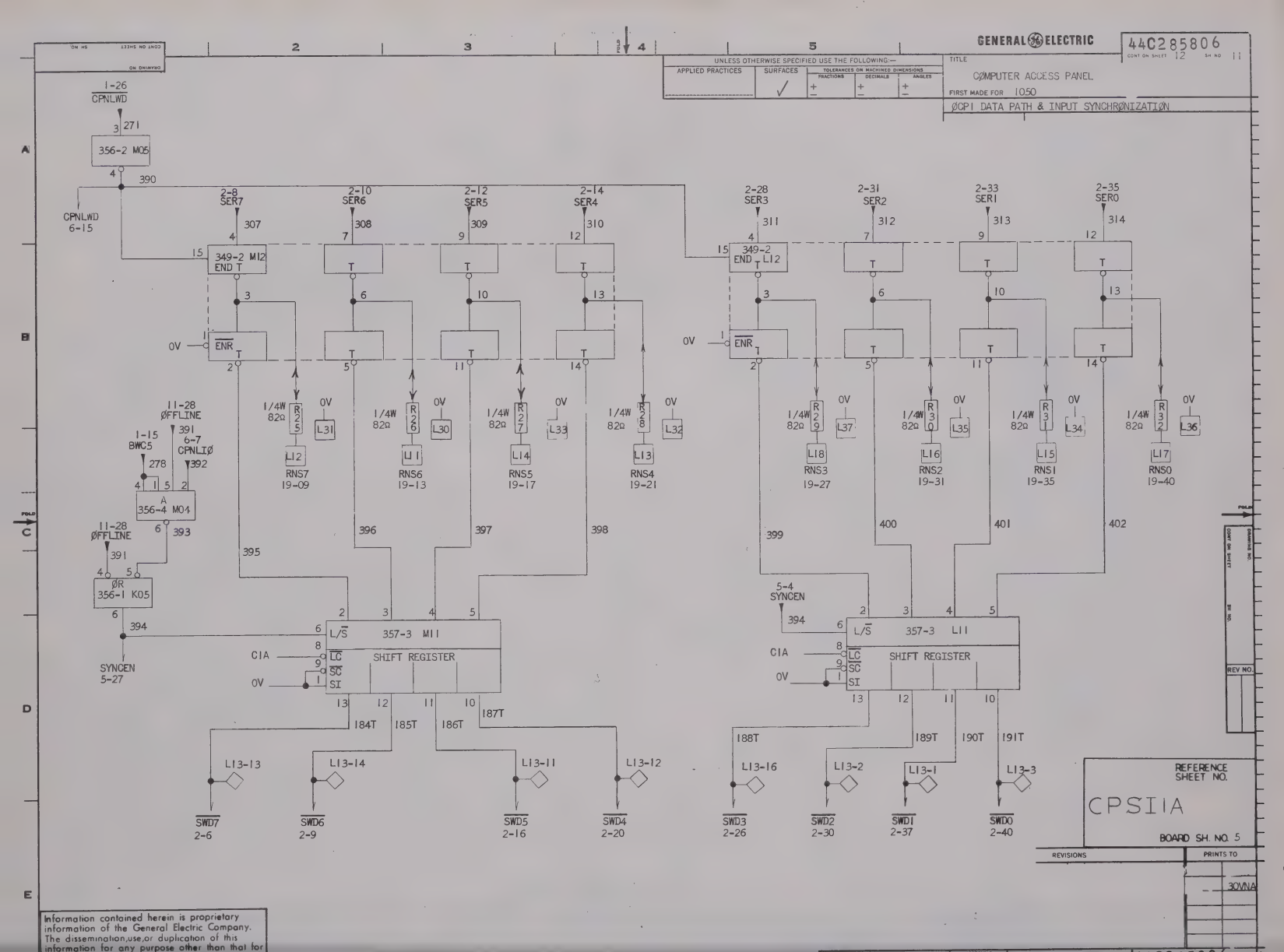
GENERAL ELECTRIC
44C285806
UNLESS OTHERWISE SPECIFIED USE THE FOLLOWING:—
APPLIED PRACTICES
SURFACES
TOLERANCES ON MACHINED DIMENSIONS
FRACTIONS
DECIMALS
ANGLES
TITLE
COMPUTER ACCESS PANEL
FIRST MADE FOR 1050
ØCP1 DATA PATH & INPUT SYNCHRONIZATION
1-26 CPNLWD
3 271
356-2 M05
4 390
CPNLWD 6-15
2-8 SER7
2-10 SER6
2-12 SER5
2-14 SER4
2-28 SER3
2-31 SER2
2-33 SER1
2-35 SER0
307
308
309
310
311
312
313
314
349-2 M12 END T
349-2 L12 END T
ENR
0V
1/4W 82Ω
R25
R26
R27
R28
R29
R30
R31
R32
L31
L30
L33
L32
L37
L35
L34
L36
L12
L11
L14
L13
L18
L16
L15
L17
RNS7 19-09
RNS6 19-13
RNS5 19-17
RNS4 19-21
RNS3 19-27
RNS2 19-31
RNS1 19-35
RNS0 19-40
11-28 ØFFLINE
391
1-15 BWC5
278
6-7 CPNLIØ
392
A 356-4 M04
393
395
396
397
398
399
400
401
402
ØR 356-1 K05
394
SYNCEN 5-27
5-4 SYNCEN
L/S
357-3 M11
357-3 L11
CIA
LC
SC
SI
SHIFT REGISTER
184T
185T
186T
187T
188T
189T
190T
191T
L13-13
L13-14
L13-11
L13-12
L13-16
L13-2
L13-1
L13-3
SWD7 2-6
SWD6 2-9
SWD5 2-16
SWD4 2-20
SWD3 2-26
SWD2 2-30
SWD1 2-37
SWD0 2-40
REFERENCE SHEET NO.
CPSIIA
BOARD SH. NO. 5
REVISIONS
PRINTS TO
30VNA
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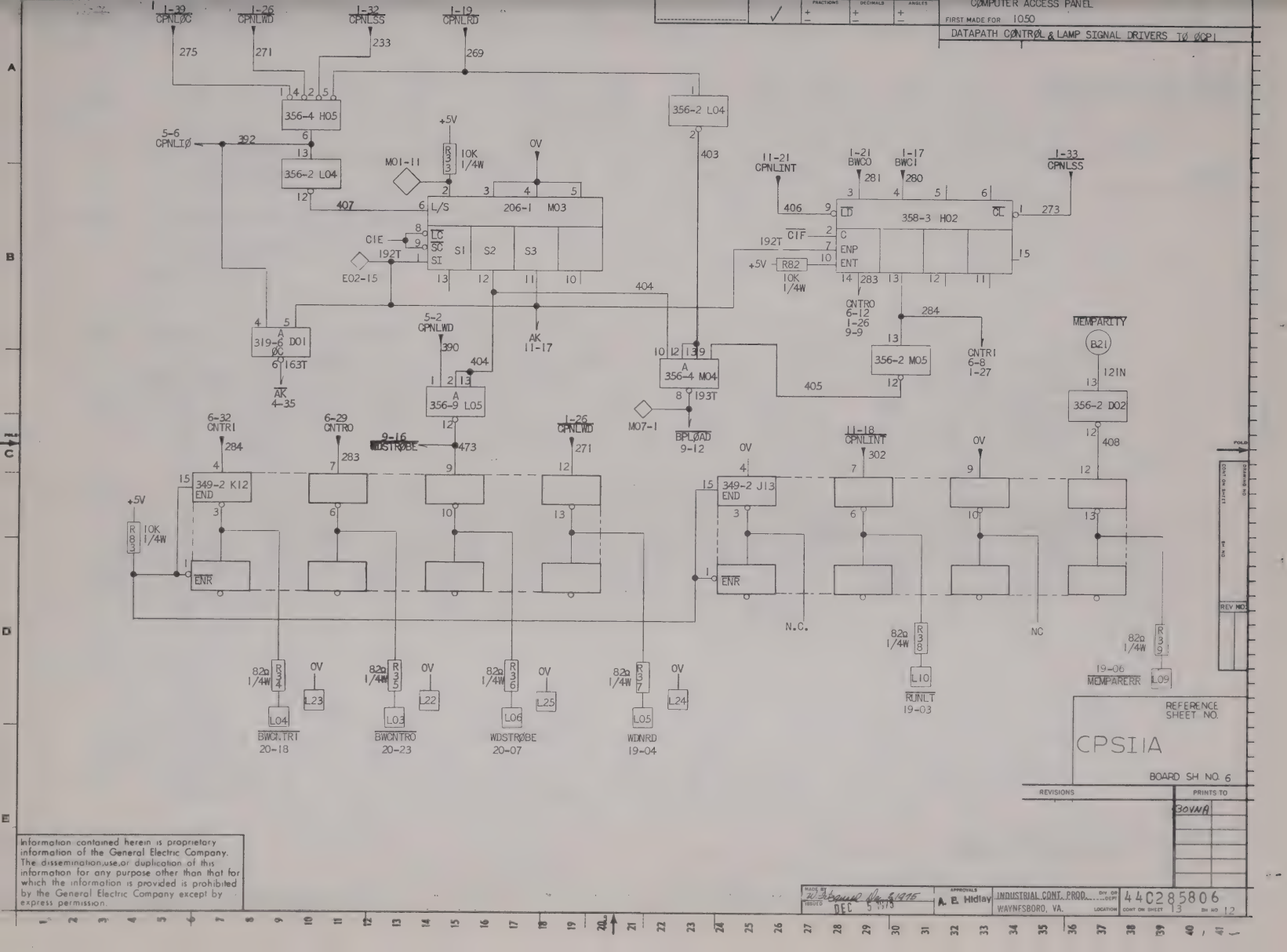
COMPUTER ACCESS PANEL
FIRST MADE FOR 1050
DATAPATH CONTROL & LAMP SIGNAL DRIVERS I/O OPI
1-39 CPNLØC
1-26 CPNLWD
1-32 CPNLSS
1-19 CPNLRD
275
271
233
269
356-4 H05
356-2 L04
5-6 CPNLIØ
392
+5V
10K 1/4W
MO1-11
OV
206-1 MO3
L/S
S1
S2
S3
C1E
192T
E02-15
407
403
404
11-21 CPNLINT
1-21 BWCO
1-17 BWCI
1-33 CPNLSS
281
280
406
358-3 H02
LD
CL
273
192T CIF
ENP
ENT
R82
10K 1/4W
+5V
283
284
CNTRO 6-12 1-26 9-9
CNTRI 6-8 1-27
356-2 MO5
MEMPARITY
B21
12IN
356-2 D02
408
319-6 DO1
163T
AK 4-35
5-2 CPNLWD
390
AK 11-17
356-9 L05
356-4 MO4
193T
MO7-1
BPLØAD 9-12
405
6-32 CNTRI
6-29 CNTRO
9-16 WDSTRØBE
1-26 CPNLWD
11-18 CPNLINT
302
271
473
283
284
349-2 K12 END
349-2 J13 END
ENR
+5V
10K 1/4W
82Ω 1/4W
R34
R35
R36
R37
R38
R39
L04
L03
L06
L05
L10
L09
BWCI.TRT 20-18
BWCNTRO 20-23
WDSTRØBE 20-07
WDNRD 19-04
RUNLT 19-03
19-06 MEMPARERR
N.C.
NC
REFERENCE SHEET NO.
CPSIIA
BOARD SH NO 6
REVISIONS
PRINTS TO
30VNA
REV NO.
FOLD
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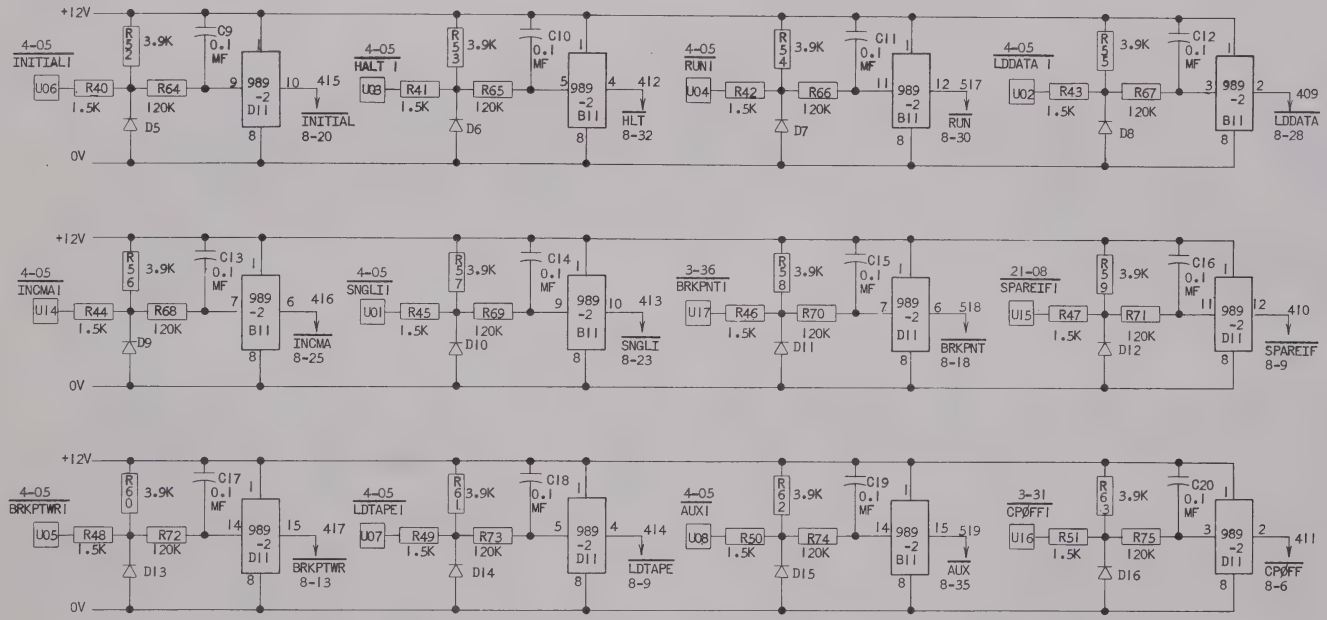
ISSUED DEC 5 1975
A. E. Hidlay
INDUSTRIAL CONT. PROD.
WAYNESBORO, VA.
440285806
CONT ON SHEET 13
SH NO 12



GENERAL NOTES

(1) SWITCHING AN INPUT FROM OPEN TO A -12V WILL CAUSE CMOS GATE OUTPUT TO GO TO A LOGIC "0" AFTER 10 MS (NOMINAL)

(2) SWITCHING AN INPUT FROM -12V TO AN OPEN WILL CAUSE CMOS GATE OUTPUT TO GO TO A LOGIC "1" AFTER 9 MS (NOMINAL)

(3) ALL RESISTORS 1/4W

(4) D5 THRU D16 44B232028-001

(5) SPARE IF FILTER CIRCUIT IS UNCOMMITTED. SEE SHEET 8 FOR SPECIAL CONNECTIONS.

REFERENCE SHEET NO.
CPSIIA
BOARD SH. NO. 7
REVISIONS
PRINTS TO
30VNR

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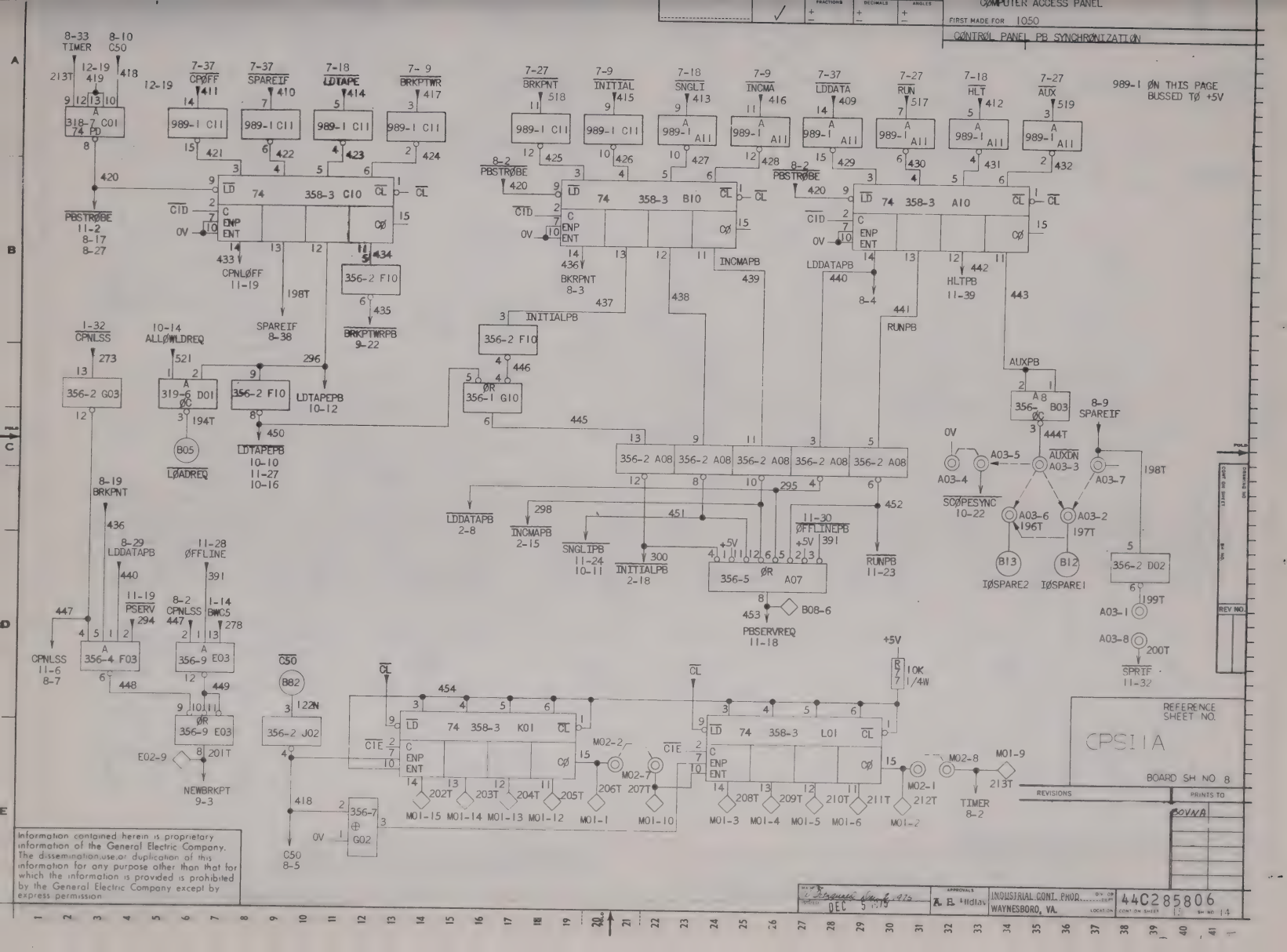
COMPUTER ACCESS PANEL
FIRST MADE FOR 1050
CONTROL PANEL PB SYNCHRONIZATION
989-1 ØN THIS PAGE BUSSED TØ +5V
8-33 TIMER
8-10 C50
7-37 CPØFF
7-37 SPAREIF
7-18 LDTAPE
7- 9 BRKPTWR
7-27 BRKPNT
7-9 INITIAL
7-18 SNGLI
7-9 INCMA
7-37 LDDATA
7-27 RUN
7-18 HLT
7-27 AUX
PBSTRØBE
CPNLØFF
SPAREIF
LDTAPEPB
BRKPTWRPB
BKRPNT
INCMAPB
LDDATAPB
HLTPB
RUNPB
INITIALPB
AUXPB
AUXØN
SØØPESYNC
IØSPARE2
IØSPARE1
SPRIF
LØADREQ
PBSERVREQ
NEWBRKPT
TIMER
CPNLSS
PSERV
ØFFLINE
BWC5
ALLØWLDREQ
LDTAPEPB
SNGLIPB
INCMAPB
ØFFLINEPB
10K 1/4W
+5V
0V
REFERENCE SHEET NO.
CPSIIA
BOARD SH NO 8
REVISIONS
PRINTS TO
BOVN/A
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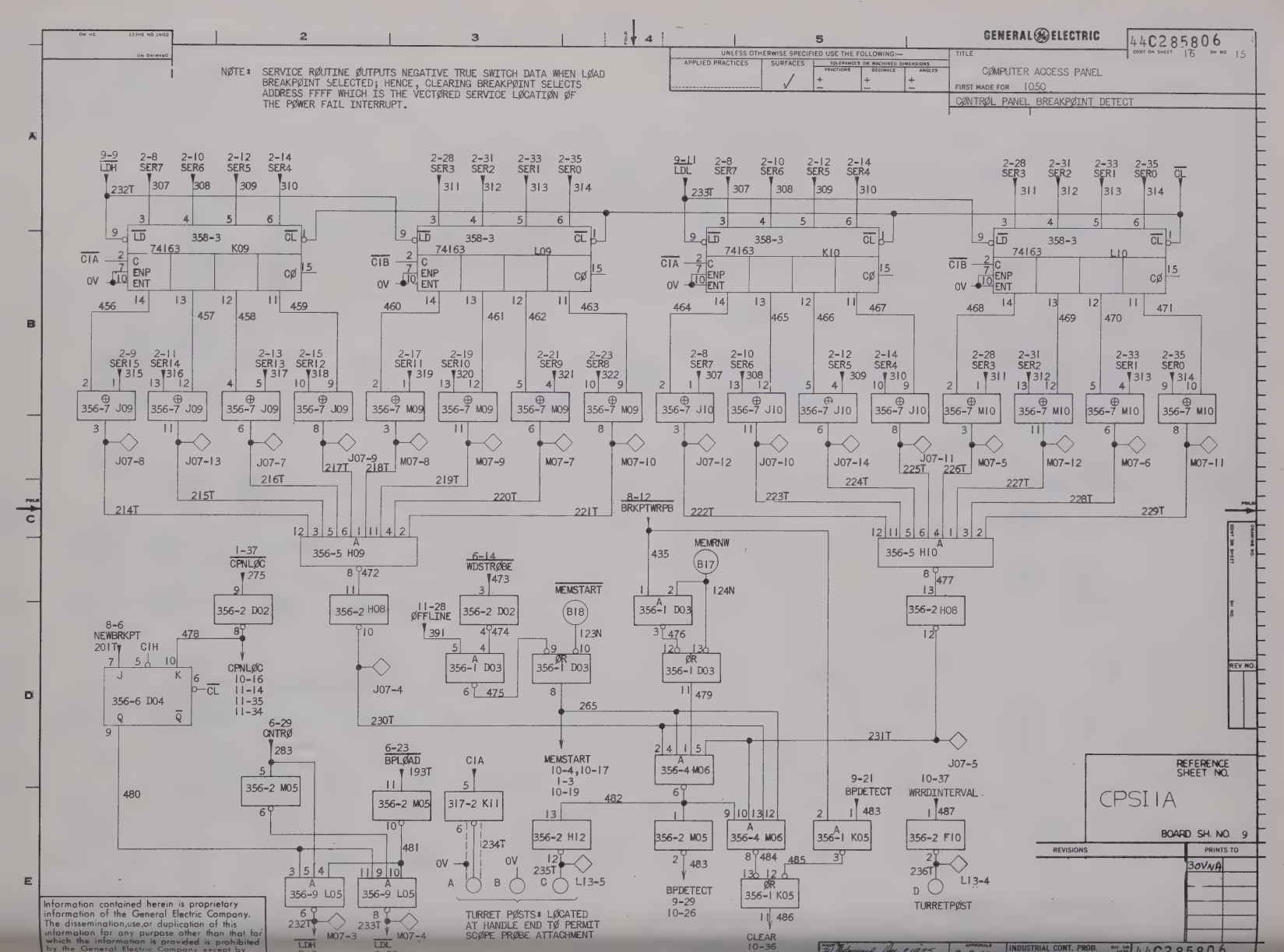
INDUSTRIAL CONT. PROD.
WAYNESBORO, VA.
44C285806
DEC 5 1975


NØTE: SERVICE RØUTINE ØUTPUTS NEGATIVE TRUE SWITCH DATA WHEN LØAD BREAKPØINT SELECTED; HENCE, CLEARING BREAKPØINT SELECTS ADDRESS FFFF WHICH IS THE VECTØRED SERVICE LØCATIØN ØF THE PØWER FAIL INTERRUPT.
GENERAL ELECTRIC
44C285806
TITLE
CØMPUTER ACCESS PANEL
FIRST MADE FOR 1050
CØNTRØL PANEL BREAKPØINT DETECT
REFERENCE SHEET NO.
CPSIIA
BOARD SH. NO. 9
REVISIONS
PRINTS TO
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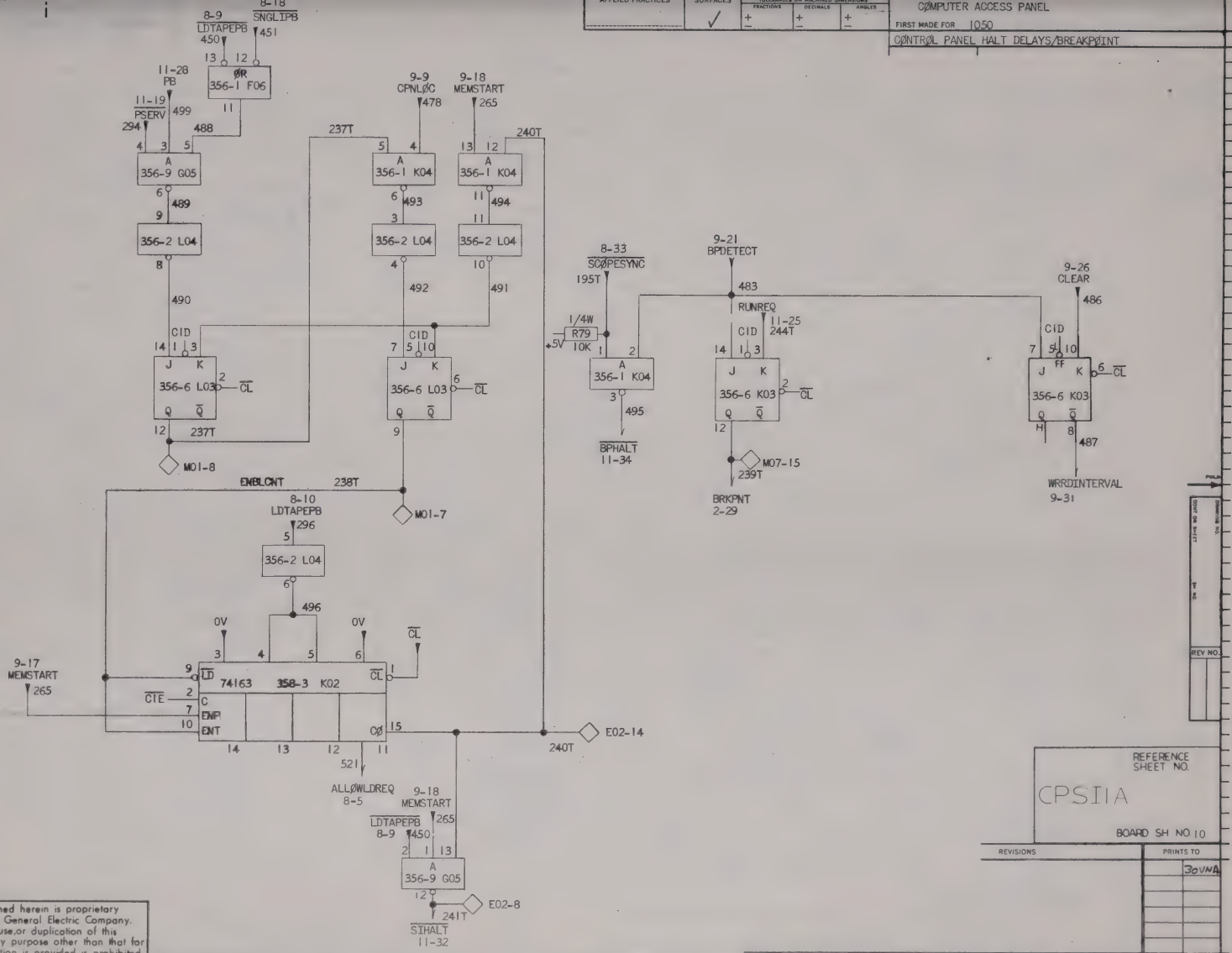
TURRET PØSTS: LØCATED AT HANDLE END TØ PERMIT SCØPE PRØBE ATTACHMENT
TURRETPØST
CLEAR 10-36
BPDETECT 9-29 10-26
INDUSTRIAL CONT. PROD.



COMPUTER ACCESS PANEL

FIRST MADE FOR 1050

CONTROL PANEL HALT DELAYS/BREAKPOINT

REFERENCE SHEET NO.

CPSIIA

BOARD SH NO 10

REVISIONS

PRINTS TO

30VNA

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DRAWN W. Bushnell DATE Nov 2, 1965

APPROVALS A. E. Hidlay

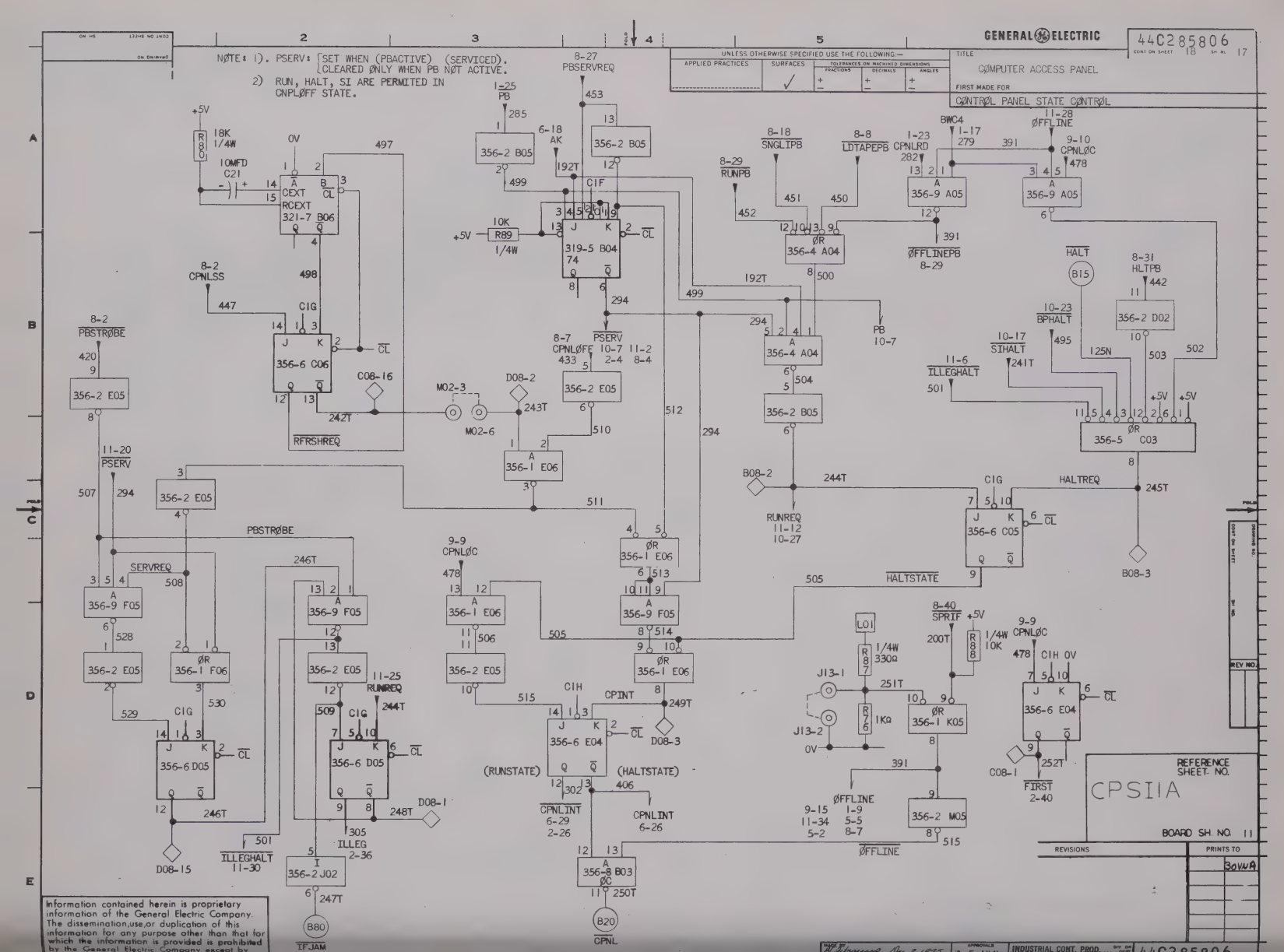
INDUSTRIAL CONT. PROD. WAYNESBORO, VA

DIV OR DEPT

LOCATION

44C285806

CONT ON SHEET 17 SH NO 16


NOTE: 1). PSERV: SET WHEN (PBACTIVE) (SERVICED).
CLEARED ONLY WHEN PB NOT ACTIVE.
2) RUN, HALT, SI ARE PERMITTED IN CNPLOFF STATE.
GENERAL ELECTRIC
44C285806
COMPUTER ACCESS PANEL
CONTROL PANEL STATE CONTROL
CPSIIA
BOARD SH. NO. 11
REFERENCE SHEET. NO.
REVISIONS
PRINTS TO
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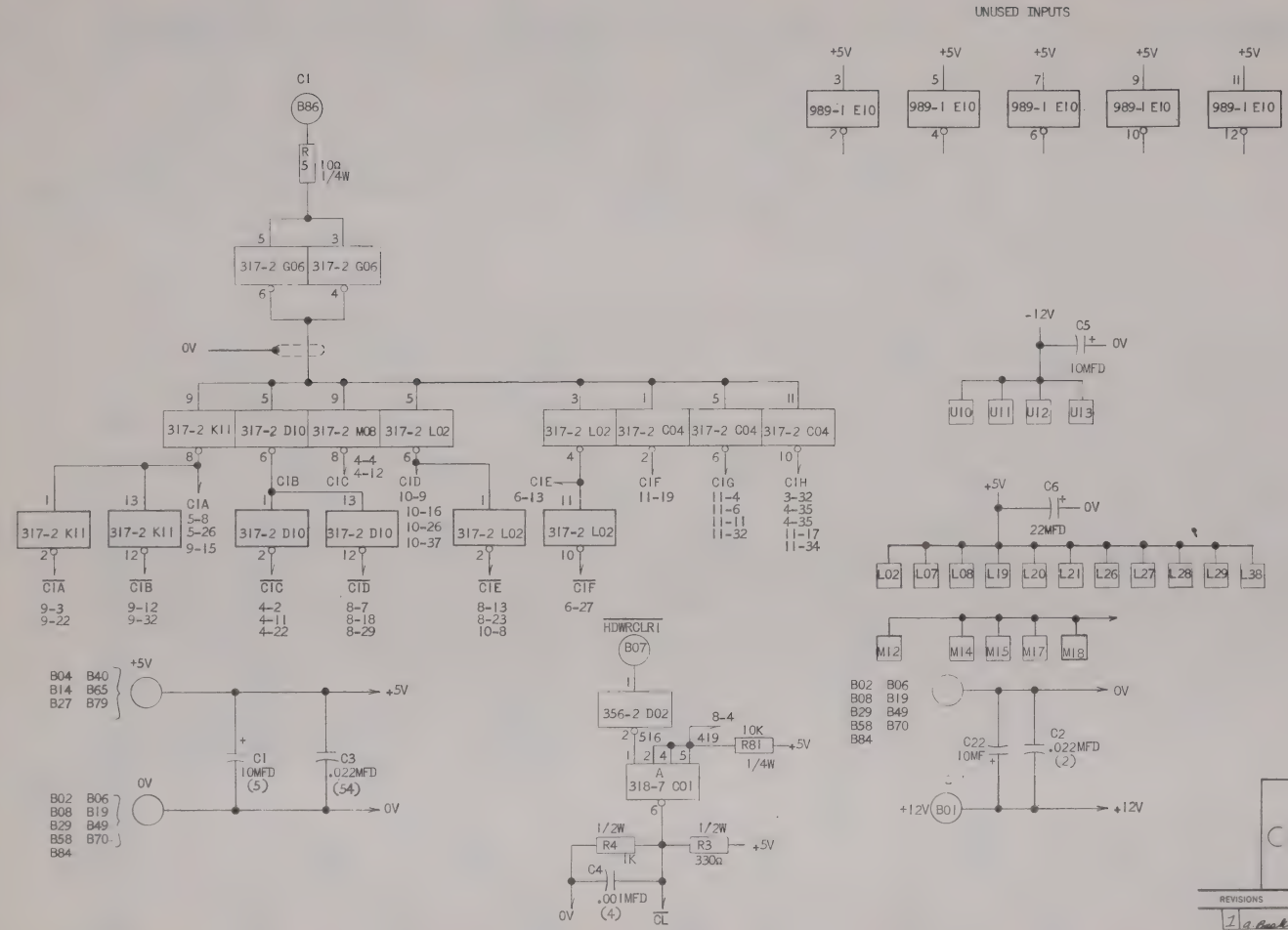
INDUSTRIAL CONT. PROD.

FIRST MADE FOR 1050

CLOCK DISTRIBUTION & DC CLEAR CIRCUIT



REFERENCE SHEET NO.

CPSIIA

BOARD SH NO 12

REVISIONS	PRINTS TO
2 a Buckler 10	30VNA

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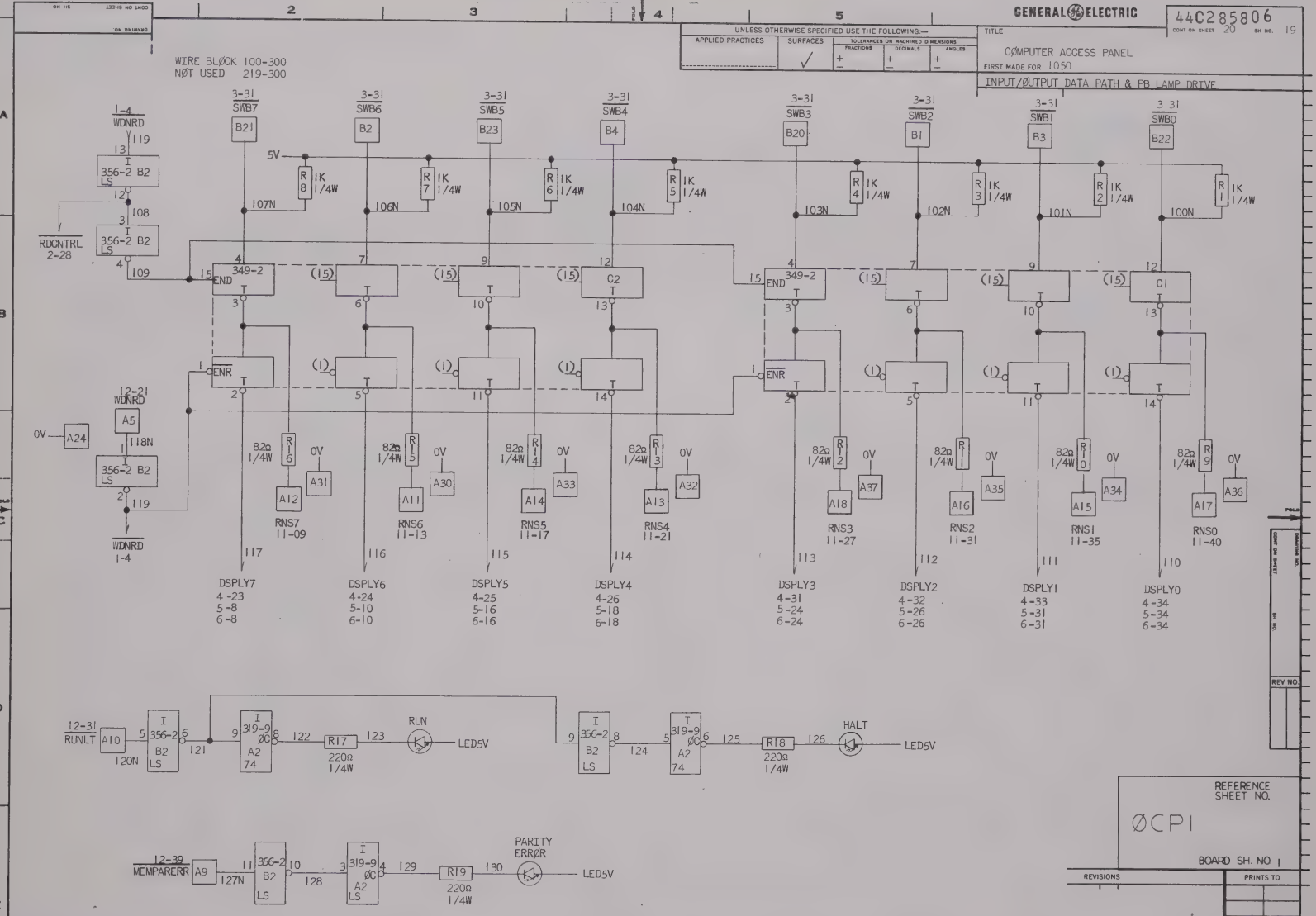
DRAWN BY N Sergeant Dec 5 1975	APPROVALS E.E. Hilday	INDUSTRIAL CONT. PROD. DIV. OF DEPT. WAYNESBORO, VA. LOCATION	44C285806 CONT ON SHEET 19	SH NO 18
DATE DEC 5 1975				



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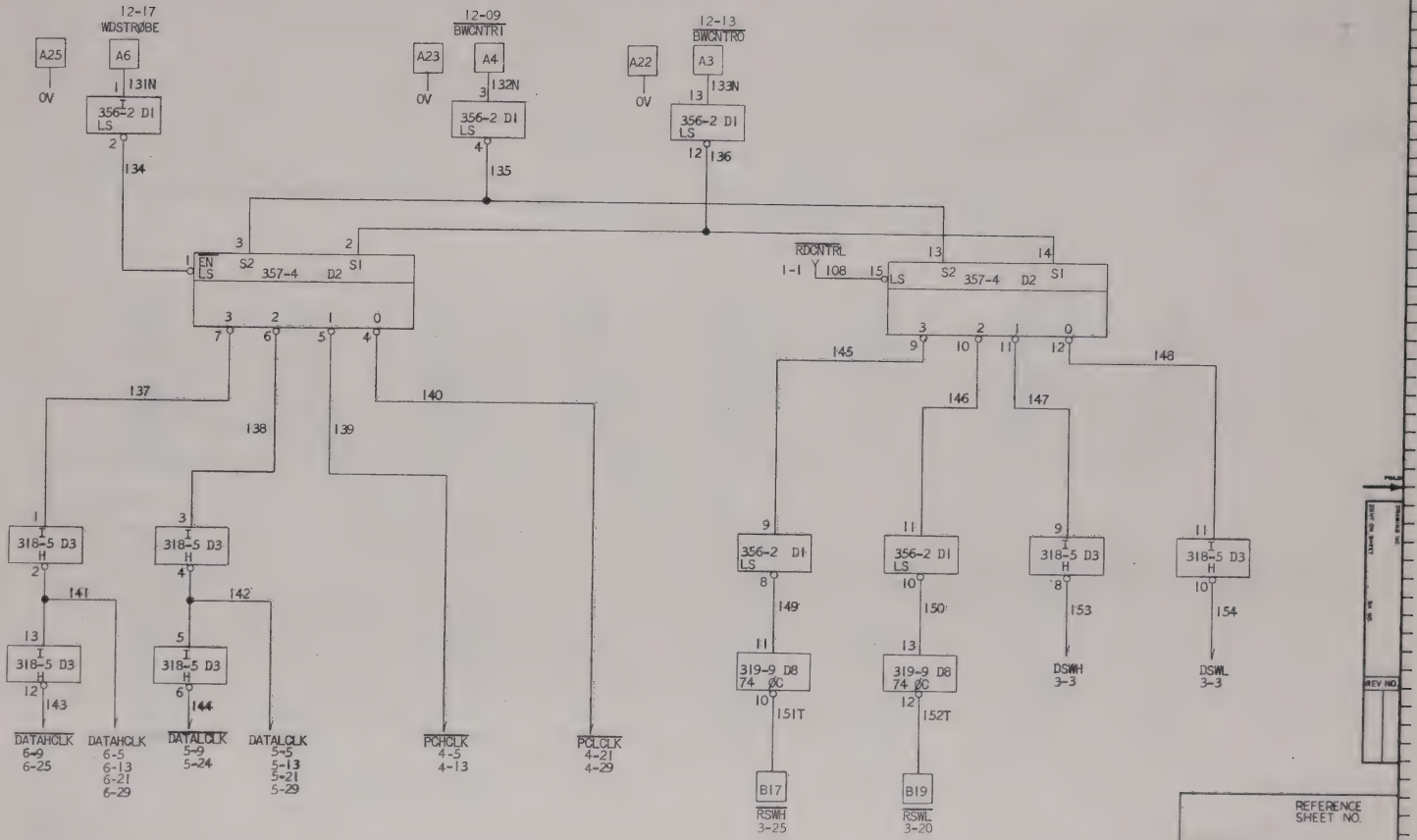
COMPUTER ACCESS PANEL
FIRST MADE FOR 1050
INPUT/ØUTPUT DATA STRØBES



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TITLE

COMPUTER ACCESS PANEL

FIRST MADE FOR 1050

DATA SWITCH DRIVERS

13-29
SPAREIFT
B27
A
B

2-39
DSWL
154

1	3	1	3	5	9	11	13
319-9 D8 74 ØC	319-9 D8 74 ØC	319-9 C8 74 ØC	319-9 C8 74 ØC	319-9 C8 74 ØC	319-9 C8 74 ØC	319-9 C8 74 ØC	319-9 C8 74 ØC
2	4	2	4	6	8	10	12
155T	156T	157T	158T	159T	160T	161T	162T
B14	B15	B10	B9	B8	B12	B13	B11
DS7 3-04	DS6 3-04	DS5 3-04	DS4 3-04	DS3 3-04	DS2 3-04	DS1 3-04	DS0 3-04

2-34
DSWH
153

5	9	1	3	5	9	11	13
319-9 D8 74 ØC	319-9 D8 74 ØC	319-9 B8 74 ØC	319-9 B8 74 ØC	319-9 B8 74 ØC	319-9 B8 74 ØC	319-9 B8 74 ØC	319-9 B8 74 ØC
6	8	2	4	6	8	10	12
163T	164T	165T	166T	167T	168T	169T	170T
B16	B18	B25	B5	B24	B26	B7	B6
DS15 3-04	DS14 3-04	DS13 3-04	DS12 3-04	DS11 3-04	DS10 3-04	DS9 3-04	DS8 3-04

A1 A2 A7 A8 A19 A20 A21 A26 A27 A28 A29 A38

A22 A23 A24 A25 A30 A31 A32 A33 A34 A35 A36 A37

+ - 22MFD C1

C2 + - 10MFD

.022 C3 (13)

LED5V +5V ALL IC PACKAGES 0V

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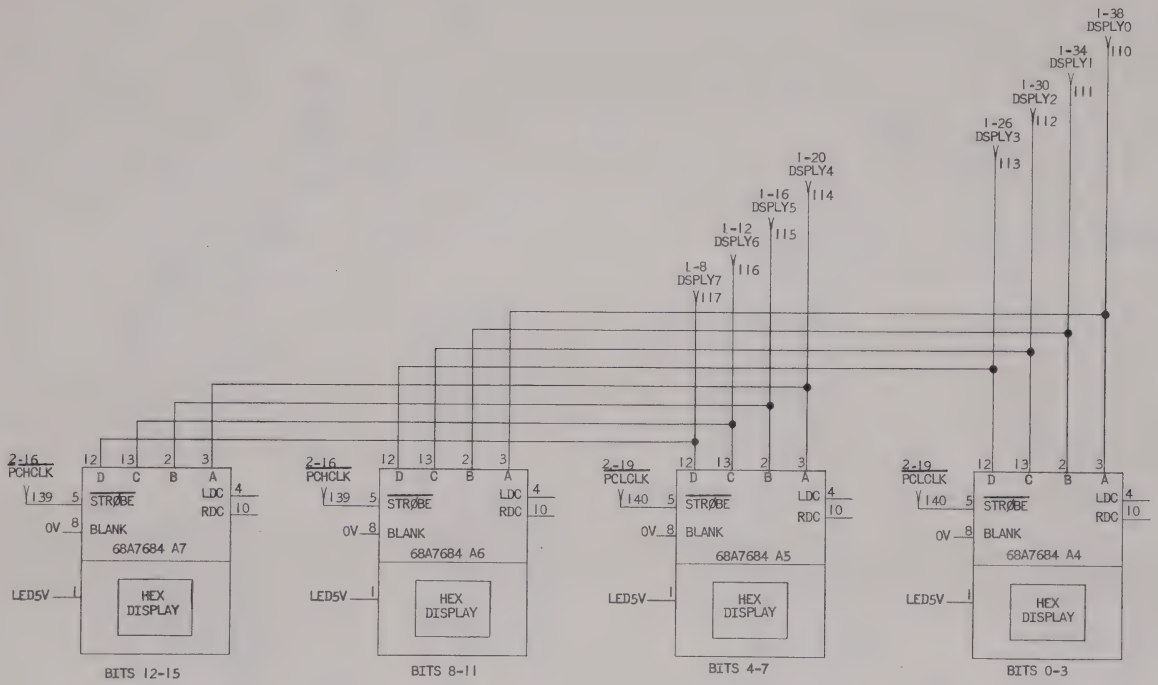
COMPUTER ACCESS PANEL

FIRST MADE FOR 1050

PROGRAM COUNTER/MEMORY ADDRESS DISPLAY



68A7684
5V = PIN 14
0V = PIN 7

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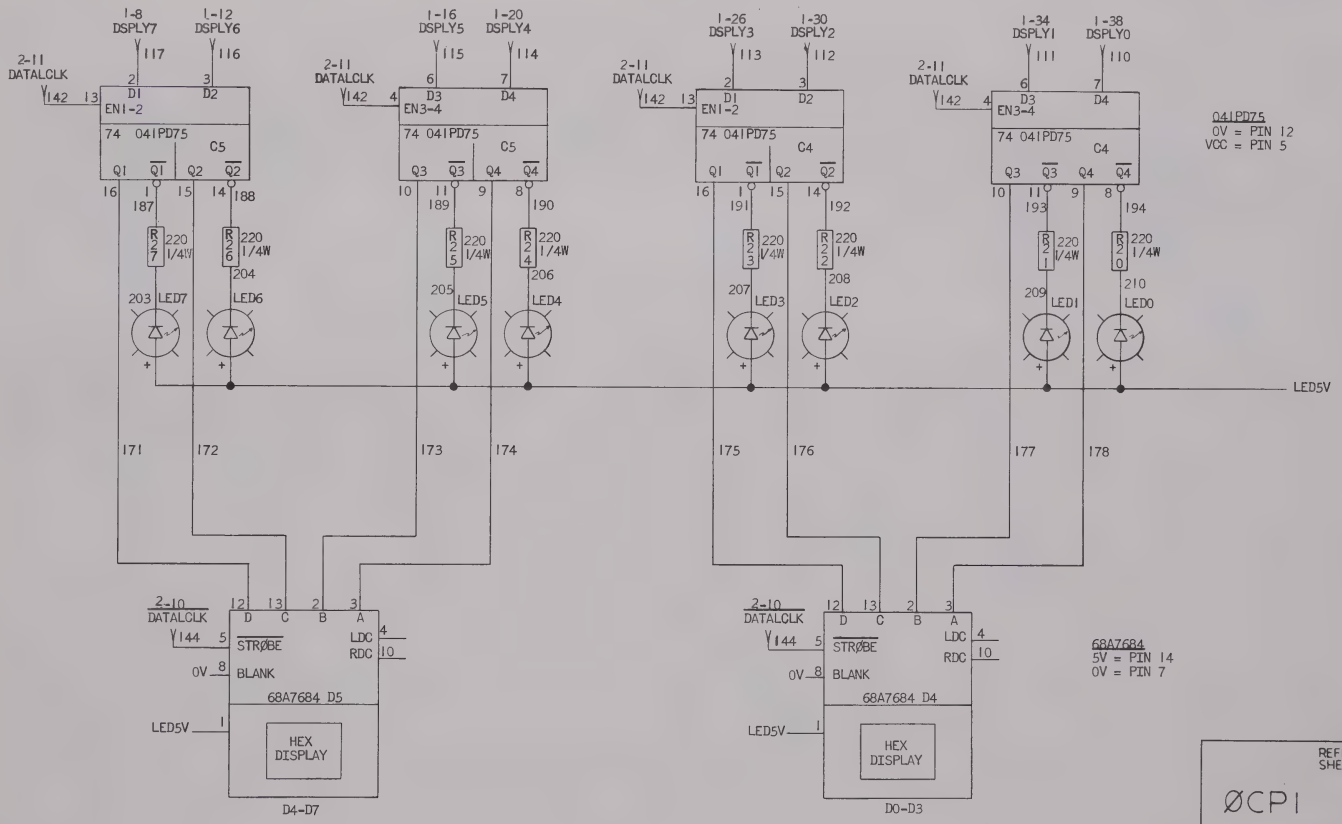
COMPUTER ACCESS PANEL

FIRST MADE FOR
DATA DISPLAY BITS 0-7



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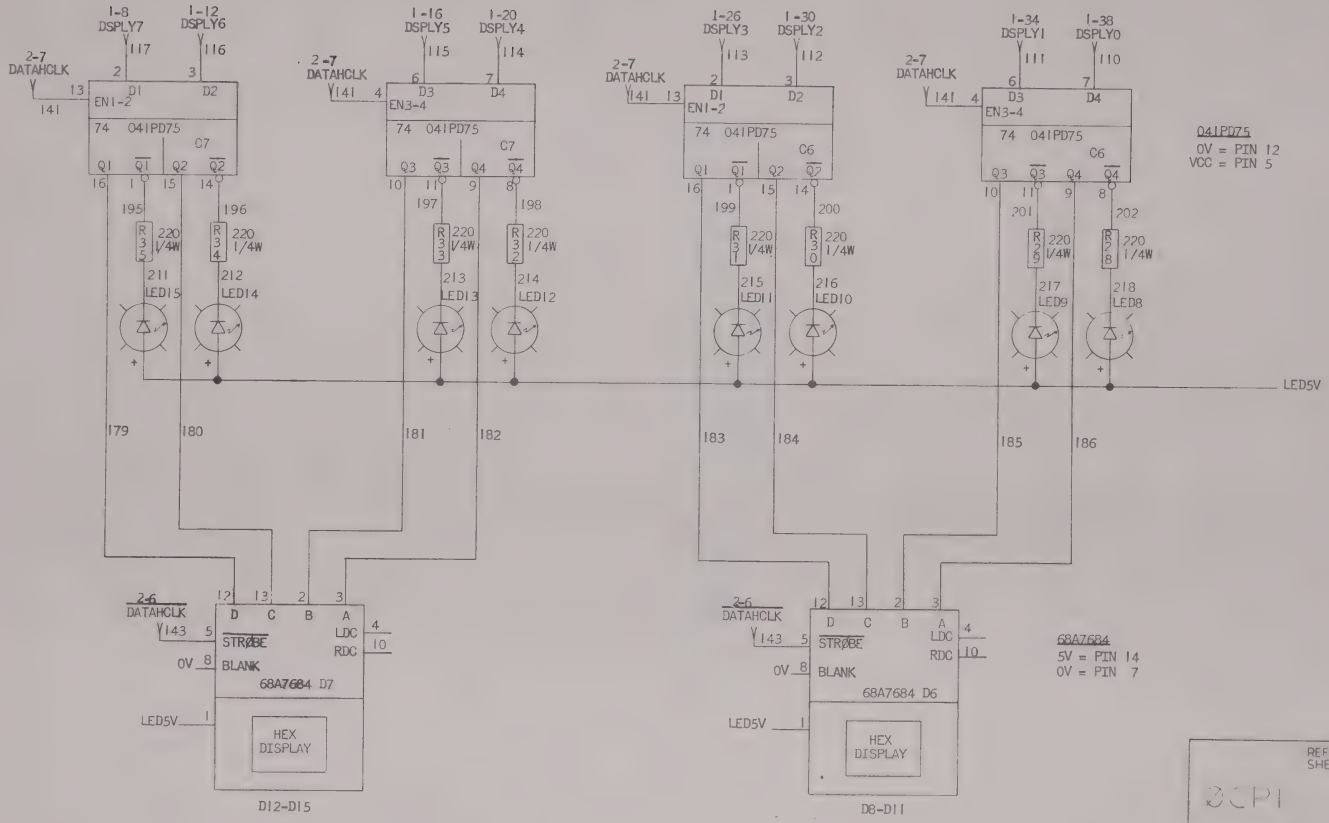
COMPUTER ACCESS PANEL

FIRST MADE FOR

DATA DISPLAY BITS 8-15



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INDUSTRIAL CONTROL DEPARTMENT, GENERAL ELECTRIC COMPANY, WAYNESBORO, VIRGINIA

PRINTED IN U.S.A.

CHAPTER X
ALPHANUMERIC DISPLAY

GEK-36040A

INSTRUCTIONS

ALPHANUMERIC DISPLAY SYSTEMS

USED IN

MARK CENTURY*

1050 MICROPROCESSOR CNC'S

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GENERAL ELECTRIC

NOVEMBER, 1976

GISTERED TRADEMARK OF GENERAL ELECTRIC CO., USA

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DRAWINGS REF.

1. 32-Character Display 44C283993
2. 256-Character Display 44C283997

Elementary diagrams for the display system are in the back of this publication.

ALPHANUMERIC DISPLAY SYSTEMS

The alphanumeric display systems described here are dot-matrix type display units using gas-discharge technology. The basic display modules are SELF-SCAN® panel displays purchased from the Burroughs Corporation. The standard 32-character readout is composed of a single row of 32 characters, and the optional 256-character readout contains 8 rows of 32 characters each.

Characters are displayed in a 5 X 7 dot matrix with 2 dot columns of spacing between successive characters. The 256-character readout has 3 dot rows of spacing between rows of characters. Dot spacing is such that the nominal character size for the 32-character readout is 0.20 X 0.14 inches and the nominal character size for the 256-character readout is 0.28 X 0.20 inches. Input data to the display units is a modified 6-bit ASCII code which allows 64 different characters to be displayed.

SELF-SCAN PANEL DISPLAY-THEORY OF OPERATION*

Although a variety of SELF-SCAN panel displays are available, the following theory of operation is basically the same for all units. This description is written to describe the 16/18 digit alphanumeric panel.

The 16/18 character display described below contains 111 columns of cavities whereas the 32-character and the 256-character displays each contain 222 columns of cavities. In addition, the 256-character display requires a minus 250-volt power source to provide the ionization potential, and it also requires the use of a 7-phase clock instead of the 3-phase clock described.

DESCRIPTION

The SELF-SCAN panel display is capable of displaying any intelligence adaptable to a dot matrix format. The panel consists of 112 columns with each column containing 7 glow cavities. One column is used for panel reset and is not visible from the display side of the panel. The display is 7 glow cavities (dots) high (1 column) by 111 columns long. This area is sufficient to display 22 characters in a 4 dot wide X 7 dot high matrix with one column of space between characters, 18 characters in 5 X 7 dot matrix with one column of dots between characters or 16 characters in a 5 X 7 dot matrix with 2 columns of space between characters. The 5 X 7 dot matrix format appears most desirable for most applications because it gives full alphanumeric capability.

OPERATION

Figure 1 is an exploded view of the left-hand section of a SELF-SCAN panel display. The panel can be thought of as having three basic sections: (1) The "glow scan" section which consists of the scan anodes and the rear side of the cathode strips, (2) The "glow priming" section which consists of tiny apertures in the cathode strips, and (3) The "glow display" section which consists of the display anodes, the center insulating sheet containing the display cavities and the front side of the cathode strips. This structure, with scan and display anode wires orthagonal to the cathodes, is hermetically sealed in a common envelope filled with a noble gas mixture composed primarily of neon.

Three basic glow discharge phenomena employed in this device are combined to produce the display. The first, glow scan, is the phenomenon where the glow is established at the back side of the reset cathode and is transferred sequentially down the entire length of the panel at the rear of each cathode at a rate of approximately 60 Hz. (This would be analogous to the scanning of a CRT if the entire face of the tube were scanned in one sweep.) This glow scan function occurs on the rear side of the panel and is not viewable from the viewing surface.

The second phenomenon is glow priming which allows the glow to be drawn from the scan side of the panel to the viewing surface. A glow is established on the rear of the cathodes and transferred down the panel to produce a scanning effect (glow scan). As the glow occurs on the rear of each cathode, metastables** diffuse through the tiny glow priming apertures in the cathode and preionize the gas in the display cavity (glow priming).

In synchronism with glow scan and glow priming, the third phenomenon, glow display, is employed where front anodes are addressed as desired and a glow is established on the front side of the cathodes in the display cavities and is visible from the viewing surface. During one complete transfer of glow down the scan side of the panel, the glow scan phenomenon occurs and each dot in the desired message is illuminated on the display side of the panel. As the glow is scanned down the complete panel at a rate of approximately 60 Hz, it follows that the dots drawn through to the viewing surface turn on and off at a rate which is above the flicker perceptability of the human eye. The result is a high-contrast, steady-state display.

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** Metastables are gas atoms that have been raised to an intermediate energy level. They cannot return to the ground state without interacting with other particles. If this interaction takes place with an atom of lower ionization energy, then the metastable causes this other atom to ionize. If the SELF-SCAN panel display, the metastables of the neon ionize the atoms of an additive gas upon collision.

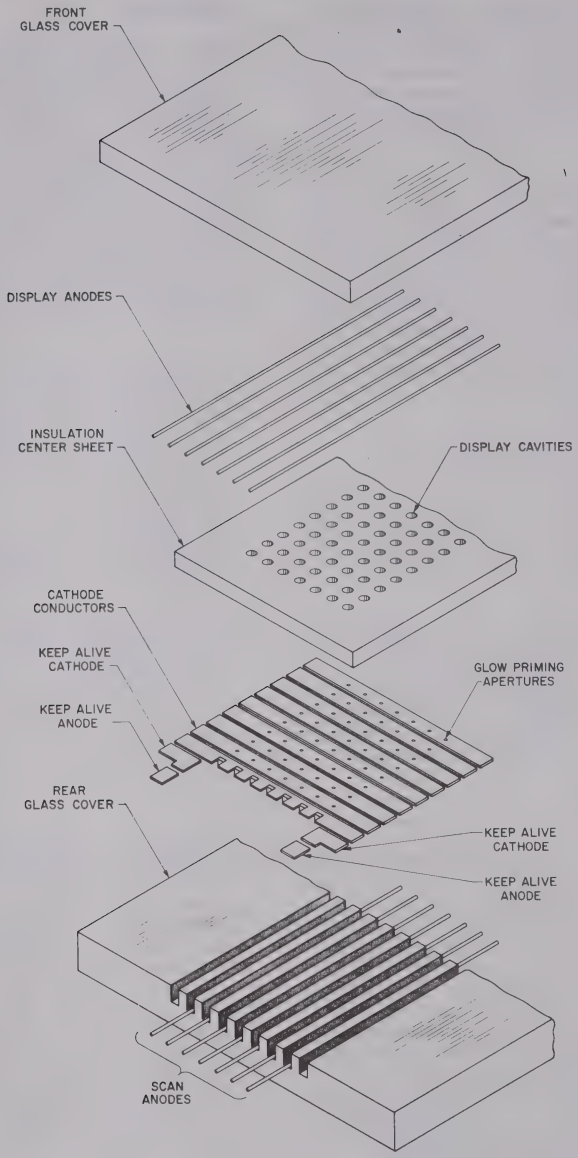


Figure 1.
SELF-SCAN PANEL DISPLAY EXPLODED VIEW

Glow Transfer

As indicated earlier, glow scan is the preferential transfer of the glow discharge from one cathode electrode onto an adjacent cathode to achieve a glow scanning effect on the rear or scan side of the panel. Figure 2 is a combination isometric and schematic drawing, designed to show the scan or rear side of the panel pictorially and the drive electronics schematically. The glow scan function occurs as follows:

1. When the panel is energized current flows between the keep-alive anodes and cathodes, and a glow discharge is established in the keep-alive grooves located in the rear plate.

2. In the vicinity of this glow discharge there is a heavy concentration of electrons, ions and metastables. The area around the keep-alive cathodes is open to allow the metastable and charged particles to diffuse into the area of the reset cathode. Two keep-alive cells, located as shown in Figure 2 are employed because the concentration of metastables decreases rapidly with distance. The construction of the reset cathode allows the metastable atoms from the 2 keep-alive cells to diffuse through the reset tabs into the scan groove area behind the reset cathode. (The glow transfer function occurs only on the rear side of the cathodes.)

3. A three-phase clock with a reset phase controls the transfer of glow down the panel. To initiate a scan, the reset input is brought to ground potential which sets both Q outputs of the J.K. flip-flops to the logic 1 and turns on the reset transistor Q_R, which grounds the reset cathode.

4. The 7 scan anodes are connected through limiting resistors to the +250 volt power source. When the reset cathode is grounded, ionization occurs that covers the 7 rectangular areas of this single cathode, defined by the intersection of the rear of the cathode strip and 7 scan grooves in the rear plate. The glow occurs within a fraction of the 125 μsec clock rate at this cathode because of the presence of the metastables which have diffused into the area from the keep-alive cells.

5. After ionization is achieved on the scan side of the reset cathode and the reset pulse is returned to logic 1, the first negative transition of the clock pulse advances the J.K. counter. (The timing diagram, Figure 3 shows the sequence of the reset pulse in relation to the clock pulses.) When the J.K. counter advances, the transistor ($Q_{Ø1}$) directly coupled to the phase 1 bus turns on and the reset transistor turns off. Consequently, all cathodes tied to the phase 1 bus (every third cathode) are brought to ground and the reset cathode is returned to +100 volts.

6. During the ionization time of the reset cathode, metastable atoms diffuse along the anode grooves to the adjacent (number 1) cathode. When the phase 1 cathode is brought to ground, ionization rapidly forms on the rear surface of cathode 1. At the same time ionization is no longer supported at the reset cathode since this electrode was returned to +100 volts. The rapid transfer of the ionization glow from the reset cathode ØR to cathode Ø1 is attributed to the high concentration of priming particles near cathode Ø1. At the same time rapid decay of the particle concentration down the panel length (from previous scan cycle) is such that the glow will only transfer to the nearest or adjacent ground cathode (in this case Ø1). Once ionization occurs at this cathode, the anode voltage drops because of the current flow through the cell to a level high enough to support ionization at the desired cathode but too low to cause ionization at any other grounded cathode. Thus the other grounded cathode in the bus will not support ionization. This concentration decay and anode voltage drop account for the smooth transfer of glow along the rear surface of the cathode.

7. The next clock pulse (Figure 3) advances the J.K. counter, turns off the bus 1 transistor ($Q_{Ø1}$) and turns on the bus 2 transistor ($Q_{Ø2}$) which resets the Ø1 cathode to +100 volts and grounds the Ø2 cathode (and all other cathodes connected to bus 2).

8. While ionization was present at the Ø1 cathode the concentration of charged particles was heaviest around the adjacent cathodes (ØR and Ø2). When the J.K. counter advanced, the Ø1 cathode was reset to +100 volts and the Ø2 cathode was grounded. As the ØR cathode was still at +100 volts, ionization could not form on the reset cathode so the glow is formed or transferred to the scan side of the Ø2 cathode.

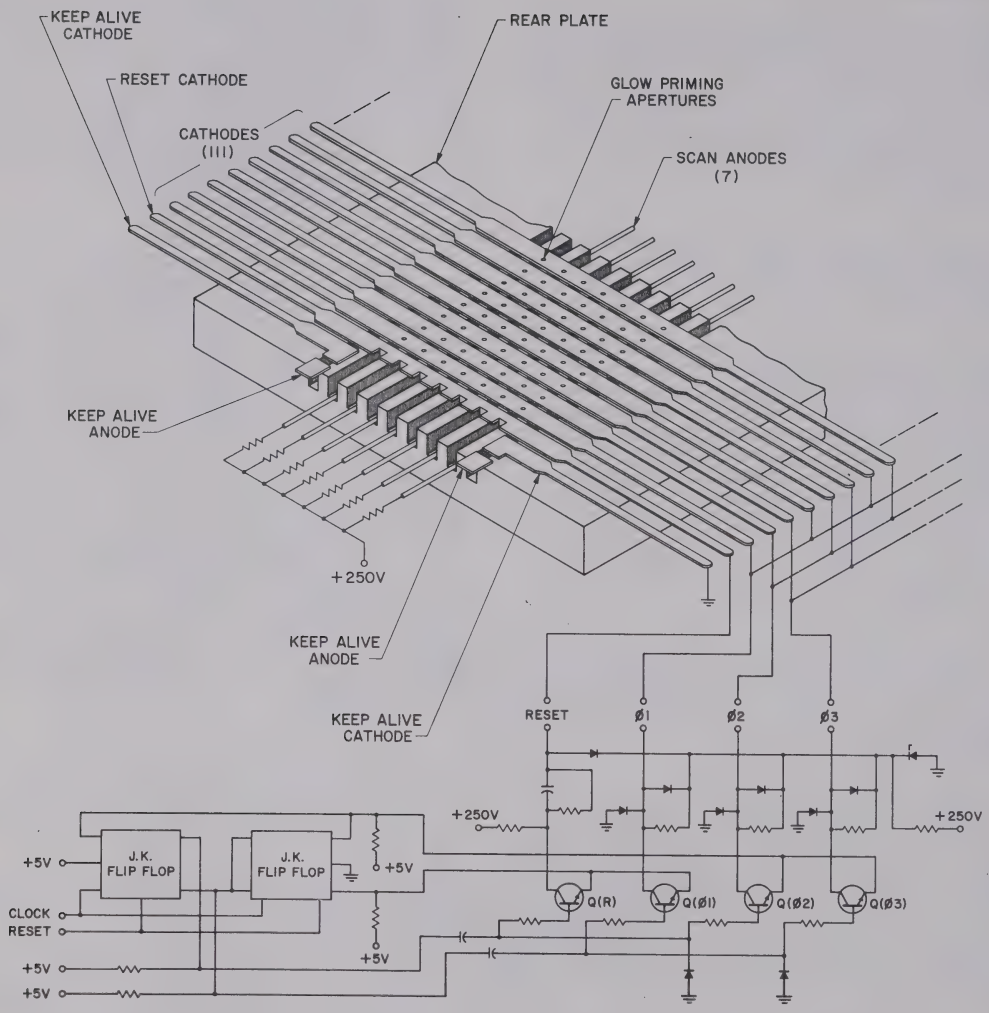


Figure 2.
GLOW SCAN PORTION OF PANEL WITH ELECTRONICS

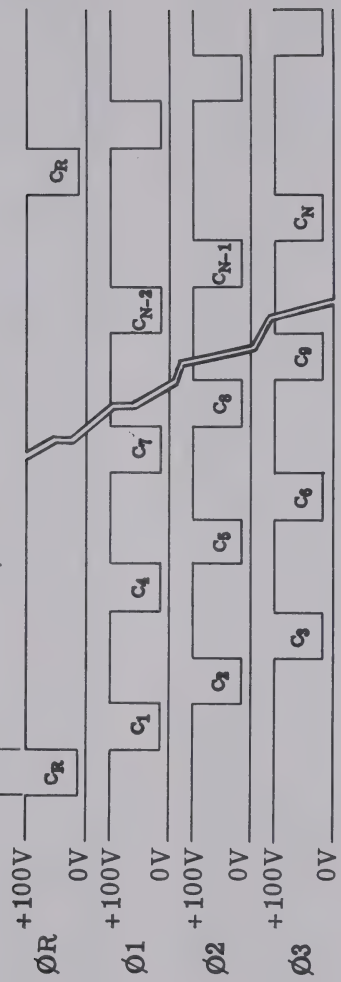


Figure 3.
TIMING DIAGRAM

9. The next clock pulse turns off the bus 2 transistor and turns on the bus 3 transistor ($Q_{Ø3}$). Cathode Ø2 is returned to +100 volts and is no longer able to sustain the ionization which transfers to the preionized and now grounded Ø3 cathode.

10. The timing signals continue to advance the J.K. counter and the cathode buses are sequentially grounded, causing the glow to transfer down the panel. After the glow has transferred to the last cathode in the display, the reset pulse again grounds the ØR cathode and the scan cycle begins again.

11. The complete scan is accomplished at a rate in excess of 60 Hz to ensure a flicker-free display.

The 16/18 digit alphanumeric panel has 112 columns. In order to maintain the 60 cycle refresh rate it is necessary to accomplish one complete scan in 1/60 sec. or 16.6ms. If each cathode is scanned within the 16.6ms limit, then each cathode strip is "on" for a period of 16.6 ÷ 112 or approximately 150 μsec. If it was desired to scan the panel in excess of 60 cycles, say at 70 cycles, then one complete scan would have to be completed at 1/70 sec or 14.2ms. This means the on time of each cathode (in the 112 cathode panel) would be 14.2 ÷ 112 or approximately 125 μsec.

There is a limit to the amount that frequency can be increased and this is determined by the off time of the cathodes. By referring to Figure 2 you see that Ø1 bus is connected to cathodes number 1 and 4. When cathode 1 goes to ground so does 4; however, as described above, the glow only appears at cathode 1. When cathode 1 is turned off the glow moves to cathode 2 and the ionization at cathode 1 starts to decay. When cathode 4 goes to ground (and cathode 1) it is imperative that ionization around cathode 1 has reduced below the point where a glow discharge will form again on this cathode or it would cause the scan to malfunction. To ensure a sufficient ionization decay, a cathode must remain off for approximately 2 clock times (approximately 250 μsec) before the bus connected to that cathode is grounded again. Increasing the length of the panel above 112 columns has the same effect as increasing the frequency because the larger number of cathodes must be scanned in the same time frame. The increased number of cathodes reduces the cathode on time (and also the off time).

If a display much longer than the 16/18 digit panel is required, then an adjustment must be made to increase the effective off time of each cathode. The obvious solution is to employ a 6-phase clock instead of the 3-phase clock shown here. In a 6-phase clock arrangement every sixth cathode is tied together instead of every third, which means the off time of the cathode is more than doubled and more cathodes can be added without exceeding the "off time" limit.

The cells on the scan side of the panel have a suitable differential between ionization and sustaining voltage. This margin is necessary when a cathode is activated, to assure that the potential of the scan anodes is reduced below the ionization potential of the remaining grounded cathodes along the display. Thus the display is statically stable and could be operated at nearly any scanning rate provided that power dissipation limits are observed.

Glow Priming

As the glow is scanned down the panel the second phenomenon, glow priming, occurs. It is illustrated by Figure 4, a cut-away cross sectional view of a SELF-SCAN panel display. This cross-sectional drawing depicts one cathode with a glow discharge on the scan side. The scan glow covers the rectangular portion on the scan side of the cathode located beneath each display cavity.

Seven tiny glow priming apertures are located through the cathode strips directly behind each display cavity. These tiny, .003 inch, priming apertures are the only connection point between the scan side and the display side of the panel. Although the gas discharge which has transferred to this cathode covers the priming apertures, their small size prohibits the glow from leaking through to the display side of the cathode. However, metastables produced by this rear glow discharge diffuse through the priming aperture to the viewing cavity and establish a metastable concentration (glow priming) in the viewing cell. This condition exists for all 7 display cells in the column. (In the illustration, metastables are represented by dots.) If the display anodes are held at +120 volts, the display cells will not ionize and the primed cells will not look any different from unprimed cells. However, if any of the display anodes are connected to the +250 volts through an appropriate limiting resis-

tor, then the corresponding primed display cavity will ionize giving bright glow discharge. (This is the condition shown in Figure 4 of the second and fourth from the top, display cells.)

The display cells, much like the scan cells, are designed for a suitable margin between ionization potential and sustaining voltage. The ionization potential is typically close to 200 volts while the sustaining voltage is 150 volts. The internal cell impedance is on the order of 15K ohms. This wide margin between firing and sustaining voltages exists for all unprimed cells.

When a display cell is primed, its ionization potential is reduced nearly to the sustaining voltage. Therefore the primed display cell will begin to support a glow discharge once its anode is raised slightly above +130 volts (a primed display will ionize typically in approximately 2 μsec). The current in a display cell can be increased to a point where the cell voltage drop approaches the ionization potential of unprimed cells.

Glow Display

Characters are written on the viewing side of the panel by addressing the display anode wires in synchronism with the glow priming ionization present on the scan side of the cathode that intersects the point where the dot is to appear. When this condition exists and the display anode is brought up to +250 volts, the metastables that have diffused to the front display cavity allow the gas between the display side of the cathode and the display anode to ionize. This glow display is the third phenomenon used in the SELF-SCAN panel display. To accomplish this timing, the same clock pulse that controls the glow priming is connected to the character generator and controls the intelligence output of this device (refer to Figure 5, Block Diagram).

The display anodes (these are the anodes located on the front side of the panel, refer to Figure 1) are coupled to the character generator through a level shifting circuit consisting of a drive transistor, a resistor, and 2 diodes. When the character generator indicates a dot is to be displayed, this circuit couples the display anode to the +250 volt power source through a limiting resistor. When the character generator indicates that a dot should not be displayed, the circuit clamps the display anode at +120 volts which is below the voltage necessary to either ionize or sustain ionization. When initiating a glow display dot, it is necessary to delay the display anode energization until after the glow scan has been transferred to that cathode and the metastables have diffused from the scan surface of the cathode to the viewing cavity. This delay, of approximately 15 μsec, is achieved by using a capacitively coupled one-shot multivibrator to inhibit the anode drivers for this time period.

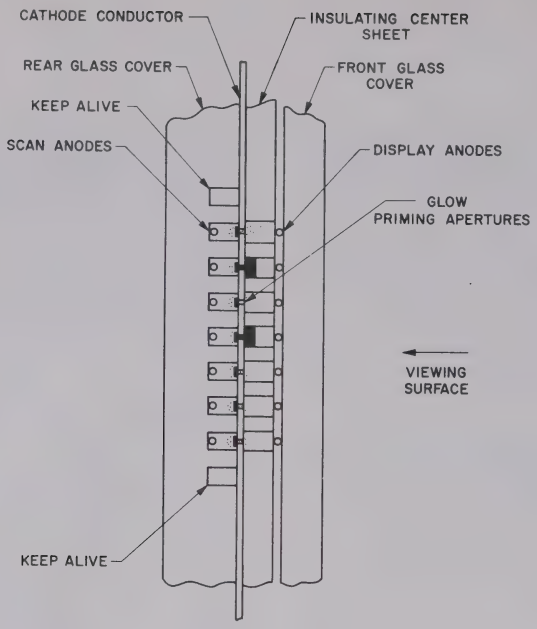


Figure 4.
CROSS SECTIONAL VIEW

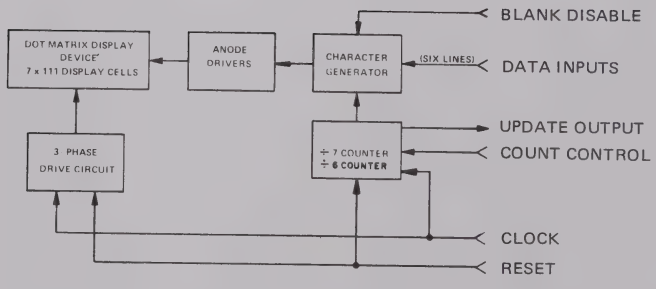


Figure 5.
BLOCK DIAGRAM

Ref. 51-4
Ref. 51-5

CHARACTER GENERATOR

The character generator is an MOS Read Only Memory chip with an internal counter, and it generates the specific dot pattern for a character. The character generator is shown in a functional block diagram in Figure 6 below.

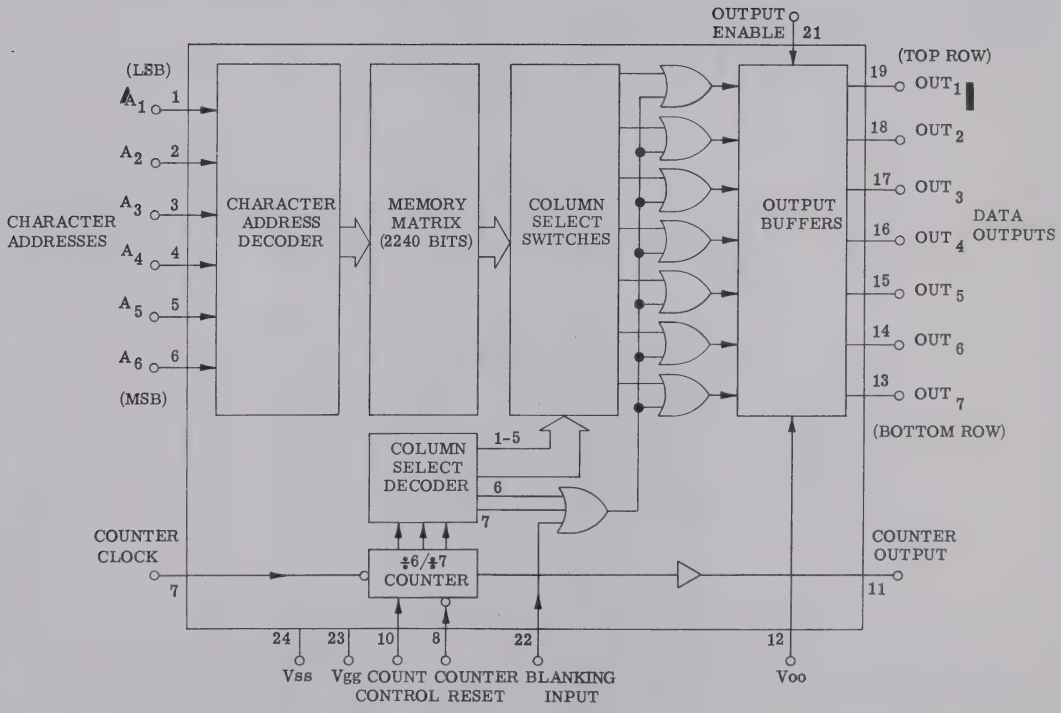


Figure 6.
FUNCTIONAL BLOCK DIAGRAM OF CHARACTER GENERATOR

Six-bit ASCII codes are presented to the character generator at the character address inputs for selection of the characters. The character generator has a 64-character repertoire generated on a 5 X 7 matrix, and it provides for either 1 or 2 columns of spacing between successive characters. Output data is generated on a column basis on 7 output lines, the column being selected by the state of the internal counter. Pulsing the counter at the counter clock input causes the column information to appear sequentially beginning with the left-most column. Output data is such that a "low" on the output lines give a "dot-on" condition.

The count control input controls the internal counter and causes the counter to divide by 6 for 1 column of intercharacter spacing or to divide by 7 for 2 columns of intercharacter spacing. Two-character spacing is used for the display systems being described. When the last count is reached, a pulse is provided at the counter output line which indicates that the next character can be supplied to the input. The counter reset input forces the counter to the state which selects the last intercharacter spacing column and is thus a means of synchronizing operation of the character generator with other system components.

The blanking input allows the data output lines to be driven high to the dot-off condition without affecting any other character generator function. Also, the output enable input allows the output lines to be open-circuited for wire-ORing.

CHARACTER REPERTOIRE

The 64-character repertoire of the supplied character generator chip is a modified ASCII subact as defined in Figure 7.

B6 → / B5 → / BITS					1 0	1 1	0 0	0 1
B 4	B 3	B 2	B 1	COL: → / ROW ↓	2	3	4	5
0	0	0	0	0	SP	0	@	P
0	0	0	1	1	!	1	A	Q
0	0	1	0	2	"	2	B	R
0	0	1	1	3	#	3	C	S
0	1	0	0	4	$	4	D	T
0	1	0	1	5	%	5	E	U
0	1	1	0	6	&	6	F	V
0	1	1	1	7	'	7	G	W
1	0	0	0	8	(	8	H	X
1	0	0	1	9	)	9	I	Y
1	0	1	0	10	*	:	J	Z
1	0	1	1	11	+	;	K	[
1	1	0	0	12	,	<	L	~
1	1	0	1	13	-	=	M	]
1	1	1	0	14	.	>	N	{
1	1	1	1	15	/	?	O	}

Figure 7.
CHARACTER GENERATOR REPERTOIRE

The dot matrix character pattern of the supplied character generator chip is shown in Figure 8 below.

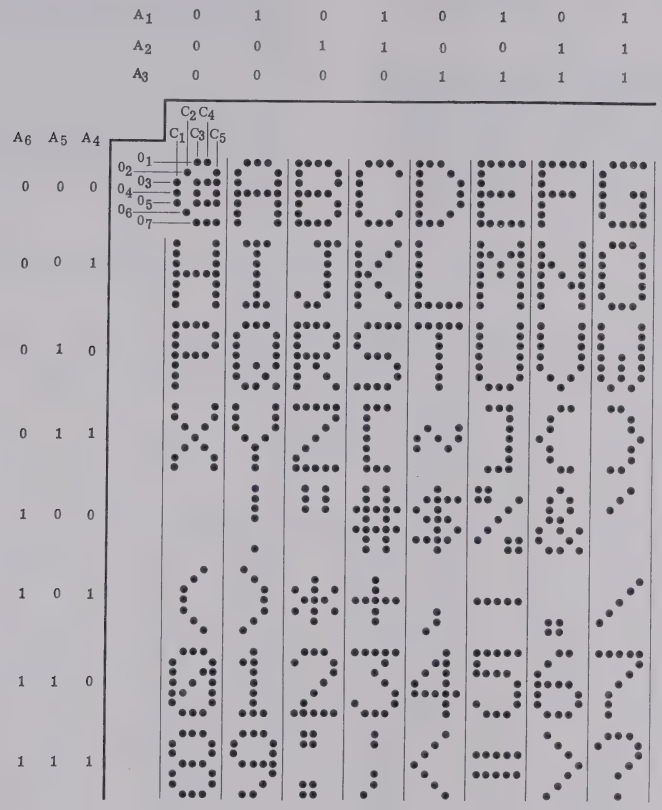


Figure 8.
DOT MATRIX CHARACTER PATTERN

SYSTEM INTERFACING

The supervisory control processor communicates with the alphanumeric display system through the PERI board. At the PERI/ADS interface, only 9 signal lines are used. Eight of these signals are input lines which control board addressing, line addressing and provide data input. One output line provides a response to the input signals.

Either the 32-character or the 256-character display may be operated from the PERI board; only one display system per board. Since 2 PERI boards are allowed per system, it would be possible to provide 2 display systems per control; however, special software would have to be developed.

Signals on the peripheral address bus control the operation of the PERI board. The board select signals are decoded and gated by the appropriate board class and operation select signals to strobe the low order system exchange bus signals to a buffer. These buffered signals are inverted and filtered to become the readout bus $\overline{ROB0}$ through $\overline{ROB6}$) signals which are presented to the display system. Also, the strobe signal mentioned above is re-synced with the C4 clock, stored, inverted, and filtered to become the $\overline{R0B7}$ signal to be used as a strobe within the display system. The display system's output signal, $\overline{RESPONSE}$, clears the stored strobe signal at C4 time, subsequently causing the $\overline{R0B7}$ signal to de-energize. Once the stored strobe signal clears, the process can be repeated to present additional information to the display system.

Since the 8 input signals to the alphanumeric display system convey both data and addressing information, their usage is as follows:

<table>
<tr><td>$\overline{ROB7}$</td><td>When energized, uses input signals $\overline{ROB0}$ through $\overline{ROB6}$. When de-energized, ignores input signals.</td></tr>
<tr><td>$\overline{ROB6}$</td><td>When energized, uses $\overline{ROB2}$ through $\overline{ROB5}$ for address decoding. When de-energized, uses $\overline{ROB0}$ through $\overline{ROB5}$ as data inputs if the display unit has been addressed.</td></tr>
<tr><td>$\overline{ROB5}$
$\overline{ROB4}$
$\overline{ROB3}$</td><td>Addresses the line to receive the subsequent data. For the 32-character display, all must be de-energized.
<table>
<tr><th>$\overline{ROB5}$</th><th>$\overline{ROB4}$</th><th>$\overline{ROB3}$</th><th>LINE</th></tr>
<tr><td>de-energized</td><td>de-energized</td><td>de-energized</td><td>1</td></tr>
<tr><td>de-energized</td><td>de-energized</td><td>energized</td><td>2</td></tr>
<tr><td>de-energized</td><td>energized</td><td>de-energized</td><td>3</td></tr>
<tr><td>de-energized</td><td>energized</td><td>energized</td><td>4</td></tr>
<tr><td>energized</td><td>de-energized</td><td>de-energized</td><td>5</td></tr>
<tr><td>energized</td><td>de-energized</td><td>energized</td><td>6</td></tr>
<tr><td>energized</td><td>energized</td><td>de-energized</td><td>7</td></tr>
<tr><td>energized</td><td>energized</td><td>energized</td><td>8</td></tr>
</table></td></tr>
<tr><td>$\overline{ROB2}$</td><td>When de-energized, addresses the alphanumeric display. When energized, addresses the sequence number readout display.</td></tr>
<tr><td>$\overline{ROB1}$
$\overline{ROB0}$</td><td>These signals are not used during addressing.</td></tr>
</table>

As implied above, when addressing an alphanumeric display, a line address must also be specified. For the 32-character display, this must always be line 1. Addressing for a particular character position within a line is not possible.

After addressing, the 32-character display accepts 32 consecutive characters for storage and display and must be readdressed before additional data will be accepted.

The 256-character display is different in that more than 32 characters may be accepted each time the display is addressed. For instance, if line 1 is addressed when the display unit is addressed and if 256 consecutive characters of data are output, then the display unit accepts 8 full lines of information for storage and display. However, the normal method of operation is to address each line, output the data for that line, and then repeat for the subsequent line.

The rate of transfer of data to either the 32-character display or the 256-character display is limited to 1 character per two C4 clocks or 1 character every 3.2 microseconds.

Interconnection between the PERI and the alphanumeric display system takes place through a 15-pin connector mounted on the AD32 and the AD256 boards for the 32-and 256-character display systems. Table 1 shows the pin assignment for the various signals.

Table 1.
INTERFACE PIN ASSIGNMENT

PIN (1 PL)	SIGNAL	
A	$\overline{\text{ROB4}}$	
B	$\overline{\text{ROB5}}$	
C	$\overline{\text{ROB7}}$	
D	$\overline{\text{ROB6}}$	
E	$\overline{\text{ROB1}}$	
F	$\overline{\text{ROB0}}$	
G	$\overline{\text{ROB3}}$	
H	+250 volts*	-250 Volts used for 256-character display, +250 volts used for 32-character display.
I	0 volts	
J	$\overline{\text{ROB2}}$	
K	$\overline{\text{RESPONSE}}$	
L	+5 volts	
M	+30 volts**	Used for 256-character display only.
N	Keying Pin	
O	-12 volts	

32-CHARACTER ALPHANUMERIC DISPLAY SYSTEM

GENERAL DESCRIPTION

The 32-character alphanumeric display system consists of an AD32 board and a 32-character SELF-SCAN display unit. A block diagram of the display system is shown in Figure 9.

The display unit (Model No. SSD132-003) contains the dot matrix display device, the anode and cathode driver circuits, the character generator, and the cathode phase generator circuit. Character size is nominally 0.20 inches high and 0.14 inches wide. Physically, the unit is approximately 8.5 inches wide by 2.25 inches high by 1.34 inches deep.

The AD32 board provides memory and control for the display unit. It contains a timing generator, load and refresh control circuits, memory and the memory address circuitry, and interfacing as required. This board is 4.5 inches by 8.5 inches and mounts on stand-offs to the back of the display unit.

Power requirements for the 32-character display system are shown in Table 2. Note that the display unit requires plus 250 volts (the 256-character display unit requires minus 250 volts). This voltage is supplied to the display unit through the AD32 board.

WARNING

THE AD32 BOARD CONTAINS DANGEROUS VOLTAGE.

Table 2.
POWER REQUIREMENTS

VOLTAGE	CURRENT	
	AD32 BOARD	DISPLAY UNIT
+5 ± 3%	1.20 A	160 ma
-12 ± 5%	------	50 ma
+250 ± 5%	------	30 ma

DETAILED DESCRIPTION

DISPLAY UNIT

Operation of the character generator and other components of the basic display unit is described on page 9.

INTERFACE

Interface signals from the PERI board are shown at the top of sheet 1 of the elementary diagrams (44C283993). The signals at this point are considered to be "low active" in that a low signal is considered to be a logic 1. Since relatively long cabling is used to interconnect the AD32 with the PERI board, filtering of the input signals is provided to decrease potential noise problems. Single or double inversion supplies required signal polarities. Refer to the section on system interfacing, page 12, for an explanation of these signals and their use.

LOAD CONTROL

Most of the load control circuitry for the AD32 board is shown on the left of sheet 2 of the elementary diagrams. The 8-input gate in package location E6 decodes the addresses. The proper combination of input signals generates the $\overline{\text{CLEARAD}}$ signal which clears the load address counter in preparation for receiving the first data character. Also, the $\overline{\text{CLEARAD}}$ signal sets the 2 flip-flops shown at the bottom left of sheet 2. The Write flip-flop enables the board to accept 32 characters of data for storage and display. The Unblank flip-flop holds the display unit in a blanked condition from the time that power is applied until the board is addressed for the first time.

$\overline{\text{CLEARAD}}$ also generates the $\overline{\text{ACCEPT}}$ signal which in turn becomes the $\overline{\text{RESPONSE}}$ signal to be sent back to the PERI board to acknowledge that the address (or data) has been accepted.

After the board has been addressed and the Write flip-flop sets, the STROBE signal activates the 3-input gate in location B6. The resulting signal also generates the $\overline{\text{RESPONSE}}$ signal and is re-synced in the third stage of shift register C4 to generate $\overline{\text{STORE}}$. $\overline{\text{STORE}}$ is routed to the address multiplexer where it gates the contents of the load address counter to the memory address lines. $\overline{\text{STORE}}$ is delayed one additional clock time at the first stage of shift register C3 and generates a one-clock time wide pulse $\overline{\text{WRITEPLS}}$ which energizes the RAM write enable input for storing input data. $\overline{\text{WRITEPLS}}$ is inverted

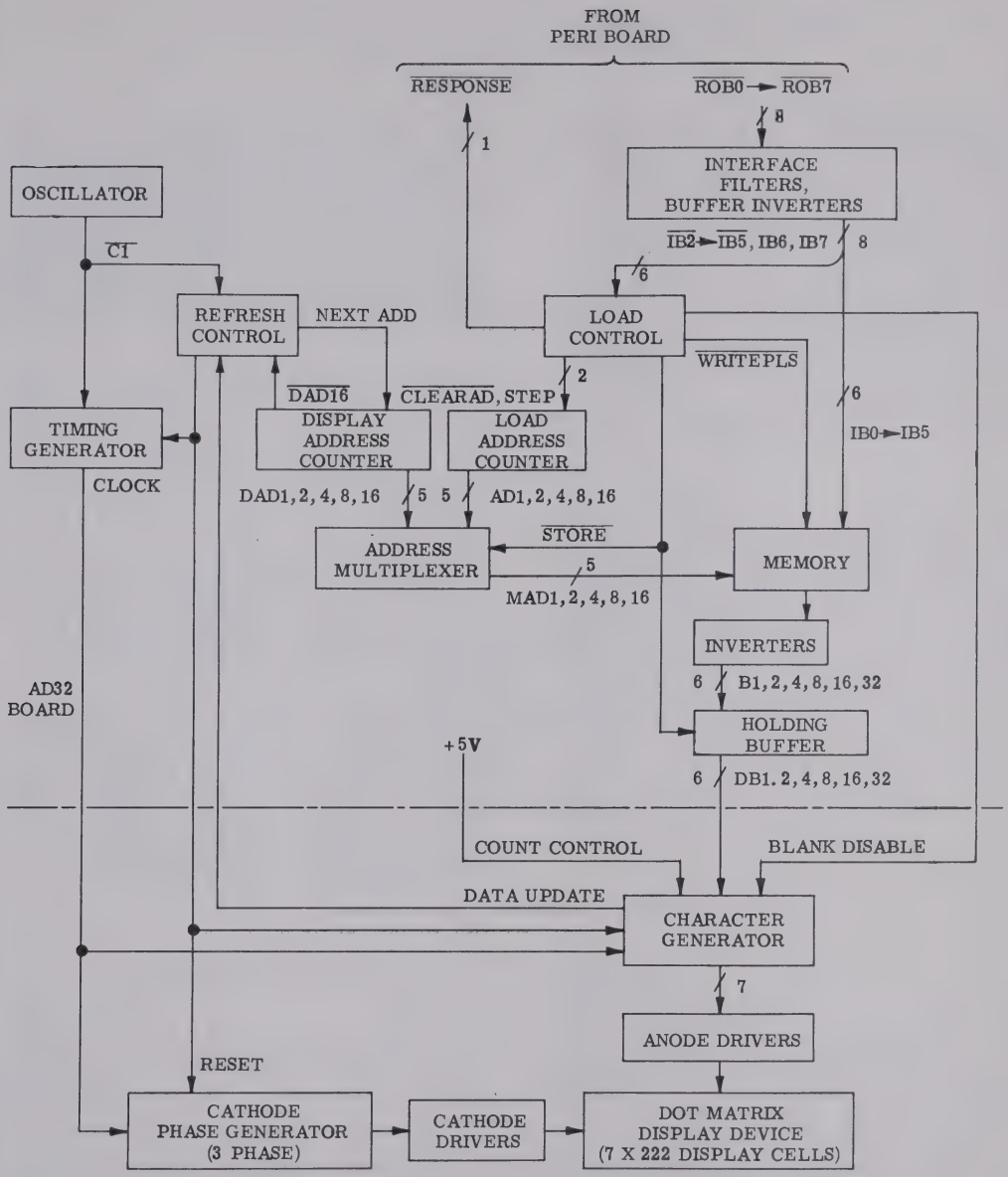


Figure 9.
BLOCK DIAGRAM OF 32-CHARACTER DISPLAY

and delayed an additional clock time to produce the STEP signal which causes the load address counter to be incremented by 1 in preparation for the next data character. When the counter is incremented after accepting the thirty-second character, the Write flip-flop clears and no more data can be accepted until the board is addressed again.

OSCILLATOR

The 10 MHz oscillator shown on sheet 4 of the elementary diagrams is divided to provide the basic system clock signal of 2.5 MHz. The duty cycle of this clock is 100/300 nanoseconds. A pair of wire wrap pins is provided so that the clock circuit can be interrupted to facilitate testing the board.

TIMING GENERATOR

The 2.5 MHz clock drives the 2 counters shown at the top of sheet 2 and generates a clock signal for use by the display unit. The first counter divides by 10 and the second divides by 16. Thus, the output signal is a square-wave with a 64-millisecond period (approximately 15.6 KHz). The display unit uses this clock signal to scan from one vertical column of dots to the next and is referred to as COLUMNCLK. Because there are 222 columns to be scanned, the scan rate of the display unit is approximately 70 hertz.

REFRESH CONTROL

Because the readout unit uses a 5 X 7 dot matrix and because it is being used with 2 dot columns between successive characters, 7 columns are required for each character. Thus, for proper display of a message, a new character must be supplied to the display unit every 7 COLUMNCLK times. The DATA UPDATE signal from the display unit logic is derived from the COLUMNCLK and indicates when the new character is to be supplied. Sheet 2 of the elementary diagrams shows a 1-clock time wide signal, NEXTADD, which is generated by the rising edge of DATA UPDATE. NEXTADD triggers the 5-stage display address counter shown at the top of sheet 3.

Since the display address is normally supplied by the address multiplexer as the RAM's memory address, the memory data is therefore available at the parallel inputs of the 2 shift registers shown at the bottom of sheet 3. This data is stored in these shift registers so that the data to the display unit will not change in the event that the address multiplexer must be switched to supply the memory address for storing input data.

The 6 shift register output signals, DB1 through DB32, are the 6-bit ASCII code of the data to be displayed. They are presented to the display unit where they are used by a character generator chip to generate the proper signals for the dot matrix display.

After the thirty-second DATA UPDATE signal from the display unit, the display address counter rolls over to the zero count to again address the first character for display. When the counter roll-over occurs, the one-shot shown at the top right-hand side of sheet 3 is triggered to generate a RESET signal for the display unit. This signal causes the next column to be scanned to be the left most column of the display, and the scan cycle repeats.

256-CHARACTER ALPHANUMERIC DISPLAY SYSTEM (MODEL NO. BDS40832-PD1)

GENERAL DESCRIPTION

The 256-character alphanumeric display system consists of an AD256 board and a 256-character SELF-SCAN display unit. A block diagram of the display system is shown in Figure 10.

The display unit (Model No. BSD40832-PD1) contains the dot matrix display device and the anode and cathode driver circuits. Character size is nominally 0.28 inches high and 0.20 inches wide. Physically, the unit is approximately 11.8 inches wide by 5.1 inches high by 1.3 inches deep.

All logic for control of the display unit is contained on the AD256 board. This includes timing, load and refresh control, memory and memory address circuitry, the cathode phase generator, the character generator, buffer and buffer control logic and interfacing as required. The AD256 board is approximately 6.8 inches by 11.8 inches and mounts on stand-offs to the back of the display unit.

WARNING

THE AD256 BOARD CONTAINS DANGEROUS VOLTAGE.

Power required by the 256-character display system is as shown in Table 3. Note that this display unit requires minus 250 volts whereas the 32-character display requires a plus 250 volt source.

Table 3.
POWER REQUIREMENTS

VOLTAGE	AD256 BOARD CURRENT	DISPLAY UNIT CURRENT
+5 ± 3%	2.0 A	150 ma
-12 ± 5%	.04 ma	---
+30 ± 5%	------	40 ma
-250 ± 30%	------	80 ma

DETAILED DESCRIPTION

DISPLAY UNIT

See page 2 for a description of the operation of the display unit.

INTERFACE

Interface signals from the PERI board are shown at the top of sheet 1 of the elementary diagrams (44C283997). Refer to page 12 System Interfacing and Table 1, page 13 "Interface Pin Assignment" for an explanation of these signals and their functions.

LOAD CONTROL

Most of the load control circuitry is shown on the left side of sheet 1 of the elementary diagrams. When the proper input signals are present at the 3-input gate E4, the $\overline{\text{STRADD}}$ signal is generated. This signal generates the $\overline{\text{RESPONSE}}$ signal which is sent back to the PERI board to acknowledge that the address (or data) has been accepted. $\overline{\text{STRADD}}$ also sets the Addressed and the Inhibit Readout flip-flops. The Addressed flip-flop, being set, allows the board to accept input data for storage. Setting of the Inhibit Readout flip-flop removes the blanking signal from the character generator. Thus, the readout is blanked from initial power up until the AD256 board is addressed for the first time.

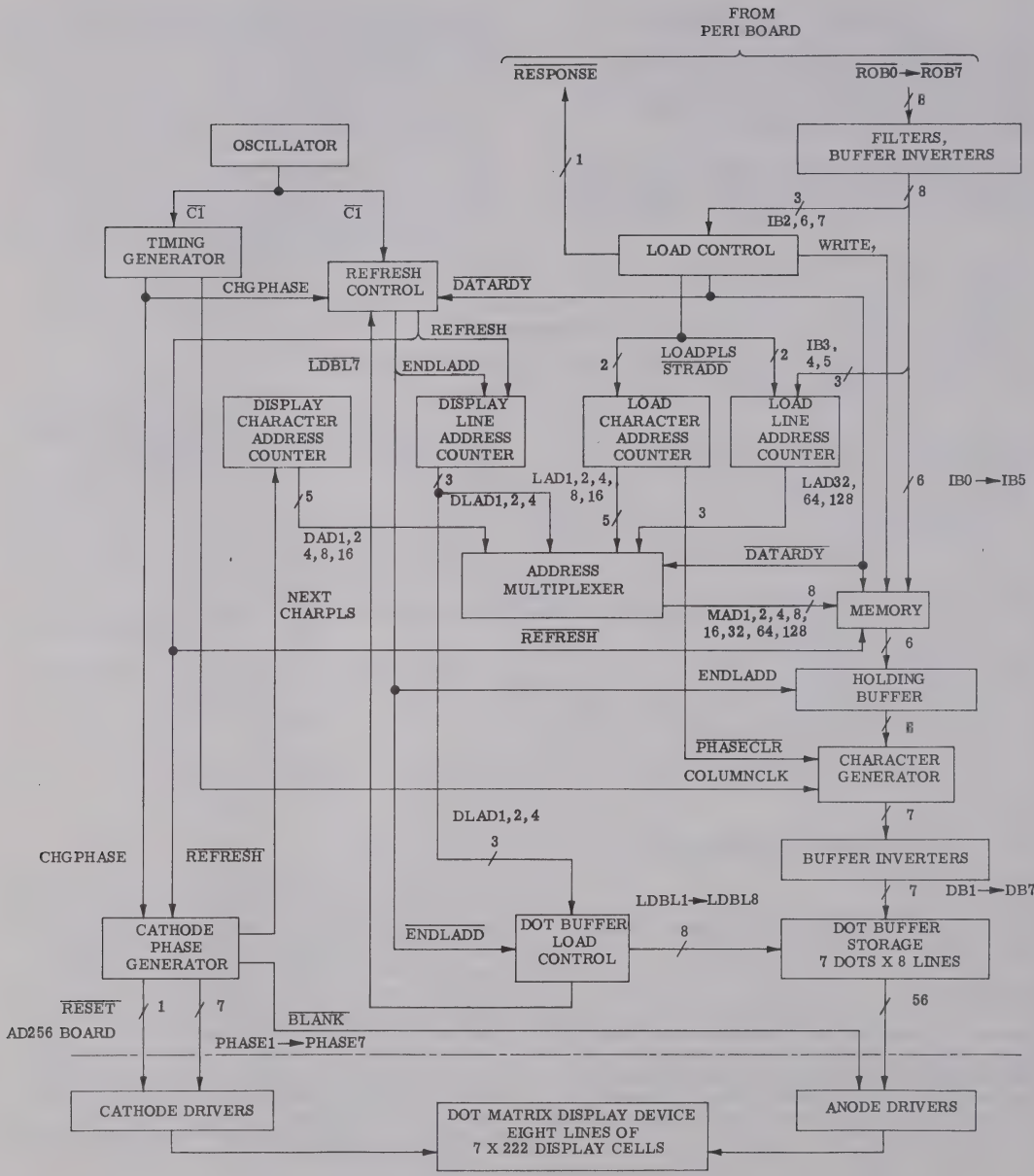


Figure 10.
BLOCK DIAGRAM OF 256-CHARACTER DISPLAY

$\overline{\text{STRADD}}$ (top left of sheet 3) causes the load address counter to be loaded. The 5 least significant bits of the counter are loaded with zero, and they control the character position within the line of thirty-two characters. The 3 most significant bits of the counter are loaded as specified by the $\overline{\text{ROB3}}$, $\overline{\text{ROB4}}$, and $\overline{\text{ROB5}}$ inputs and are considered to be an address for the line position within the 8-line display.

After the Addressed flip-flop has set, subsequent $\overline{\text{ROB7}}$ signals strobe for data to be input for storage. The primary signal used to control the loading of data is $\overline{\text{DATARDY}}$, (shown at the lower left side of sheet 1). The signal accomplishes the following tasks:

1. It generates the $\overline{\text{RESPONSE}}$ signal (sheet 1) for return of an acknowledgement to the PERI board.

2. It is used by the memory address multiplexer (sheet 3) to gate the load address counter as the memory address signals for the RAM's.

3. It enables the RAM's (sheet 4).

4. It generates the $\overline{\text{WRITE}}$ signal (sheet 4) which is used as a write pulse by the RAM's to store the input data.

5. It is used by the refresh control logic (sheet 2) to prevent display errors. It does this by inhibiting RAM data from being gated into the holding buffer while the RAM's are being addressed for input data.

6. It generates a LOADPLS signal (sheet 1) on its trailing (rising) edge, which increments the load address counter and prepares it to receive the next input data character.

Thus, since $\overline{\text{ROB7}}$ pulses are used to generate $\overline{\text{DATARDY}}$ pulses, successive $\overline{\text{ROB7}}$ pulses store input data in sequential memory locations for consecutive character positions.

Even though the load address counter is only line addressable, i.e., character address cannot be loaded; it is capable of automatic line incrementing. Therefore, if initially addressed for line 1, 256 consecutive characters can be loaded for filling all 8 lines of the display. Additional characters begin to refill the display starting at the left of line 1. Character position is reset to zero or to the first character position of the line whenever a new line is addressed.

OSCILLATOR

The 10 MHz oscillator shown on the left of sheet 2 of the elementary diagrams is divided by 4 to provide the basic system clock signal of 2.5 MHz. The duty cycle of this clock is 50/350 nanoseconds. A pair of wire wrap pins is provided so that the clock circuit can be interrupted to facilitate testing of the board.

TIMING GENERATOR

The 2.5 MHz clock directly drives the 2 counters shown at the top right side of sheet 2 and they generate a clock signal for scanning from one column of dots to the next. The first counter divides by 16 and the second divides by 8 to produce an output square-wave signal with a 51.2 millisecond period (approximately 19.5 KHz). Because there are 222 vertical columns to be scanned, the scan rate of the display unit is approximately 88 hertz.

CHARACTER GENERATOR

Operation of the character generator chip is described on page 9.

CATHODE PHASE GENERATOR

The cathode phase generator logic is shown on sheet 6 of the elementary diagrams. The rising edge of $\overline{\text{COLUMNCLK}}$ generates the CHGPHASE signal which is 1 clock time wide. CHGPHASE, in turn, generates the various phase signals required by the cathode drivers of the display unit. Each of the 7 phase signals is bused to the corresponding column of each successive character of the panel. For example, $\overline{\text{PHASE 1}}$ is bused to column one of all character positions, $\overline{\text{PHASE 2}}$ is bused to column 2, etc. Since the cathode phase generator is driven by the CHGPHASE signal, a different set of cathodes is selected each 51.2 microseconds.

Generation of the $\overline{\text{RESET}}$ and the seven sequential $\overline{\text{PHASE}}$ signals is accomplished by using a dual 2-to-4 demultiplexer to decode the contents of the phase counter which is incremented by the CHGPHASE signal. Assume initially that the phase counter contains a zero count. This generates the $\overline{\text{RESET}}$ signal which ionizes the reset cathode of the display unit. This cathode is just to the left of the most left-hand column of dots of the panel. The next CHGPHASE signal increments the counter and generates $\overline{\text{PHASE 1}}$ which transfers the scan ionization to the left-hand column of dots. Each additional CHGPHASE signal transfers the ionization one column of dots to the right.

After PHASE 7 is generated, the counter is recycled beginning with the count of 1. Thus, PHASE 1 through PHASE 7 are sequentially repeated for each successive character. After the 32nd character is scanned for display, roll over of the DISPLAY ADDRESS COUNTER triggers an 80-microsecond one-shot which generates the PHASECLR signal. This signal clears the phase counter, and again initializes the scanning of the display panel to the left of the panel.

The BLANK signal is generated during the first 19.2 microseconds of each phase signal. It prevents information intended for one column from being displayed in an adjacent column. It also prevents incorrect ionization during the updating of the dot buffers.

DOT BUFFERS

The dot buffers are shown on sheet 5 of the elementary diagrams. These buffers are 4-bit shift registers used only in the Parallel mode to hold data for presentation to the display unit. These buffers are grouped in pairs, each pair containing the dot information for 1 vertical column of 1 line. Buffers for 8 lines are required in order to present the complete vertical column to the display at the same time.

REFRESH CONTROL

Refresh control logic is shown in the center of sheet 2 of the elementary diagrams. Refreshing the display panel is a continuous, repetitive process which is interrupted only for short intervals when a data character is being input for memory storage. Here, refresh is referring to the updating of column information stored in the dot buffers; hence, it must occur in conjunction with the COLUMNCLK signal.

The CHGPHASE signal (rising edge of COLUMNCLK) sets the Refresh flip-flop, enabling the 3-input gate E4. If input data is not present DATARDY is de-energized, allowing the counter B3 to increment at the C1 clock rate. Thus, ENDLADD is present for 1 out of 4 clock times. Since DATARDY is de-energized, the memory address multiplexer gates the display address counter as the memory address and the contents of that memory address is loaded into the holding buffer at the end of the ENLADD signal.

Simultaneously with the generation of ENLADD, the line address bits of the display address counter are decoded with a dual 2-to-4 demultiplexer to generate a load dot buffer line signal which loads the present output of the character generator into the appropriate dot buffer. Also, ENLADD increments the line address portion of the display address counter in preparation for loading the next dot buffer. Additional ENDLADD signals are generated until generation of LDBL7 clears the Refresh flip-flop. By this time the dot buffers have been loaded with 1 complete vertical line of information.

For example, assume that the RESET signal has just been generated so that scanning is to begin at the left most vertical column of the display. Also, assume that the characters to be displayed are an 'A' for line 1, 'B' for line 2, etc., concluding with an 'H' for line 8. During the RESET signal, refresh occurs so that the holding buffer ends up holding an 'H' character. When the RESET period ends, the next CHGPHASE signal generates PHASE1 which scans the first vertical column and starts the refresh cycle. The line address portion of the display address counter is held clear until the refresh cycle begins, so line 1 is the first to be addressed from memory. Since the character for line 8 is already held in the holding buffer, the first ENDLADD generates LDBL8 which loads the dot representation of the first column of an 'H' into line 8. Simultaneously, the 'A' is loaded into the holding buffer and the line address portion of the display address counter is incremented to address the first character of the second line. Each successive ENDLADD signal then loads dot representation of the first column of the character contained in the holding buffer to the appropriate dot buffer while it loads the character for the next line into the holding buffer and prepares to address the subsequent line. At the end of the refresh cycle, the holding buffer contains the character for the last line.

For the next several refresh cycles, the same sequence of characters are loaded into the holding buffer. However, the character generator produces the dot representation of the next vertical column for the character to be stored into the dot buffers. Since the character address portion of the display address counter is incremented at the end of PHASE 6, the next vertical group of characters are used for refresh purposes during PHASE 7. This allows the character for line 8 to be present in the holding buffer prior to refreshing the first column of the character.

When data is being input for storage, the $\overline{\text{DATARDY}}$ signal holds the refresh counter in the cleared state thus preventing generation of ENDLADD signals for refresh purposes. As soon as $\overline{\text{DATARDY}}$ de-energizes, the counter is allowed to function, thus continuing a refresh cycle which may have been interrupted. The refresh cycle is thus extended by about 1.6 microseconds for each character that is input during the cycle.

INDUSTRIAL CONTROL DEPARTMENT, GENERAL ELECTRIC COMPANY, WAYNESBORO, VIRGINIA

WIRE BLØCK 100-250
NØT USED 219-250

32 CHARACTER ALPHANUMERIC DISPLAY
FIRST WADE FØR . M00 AD32A
R2/M00

RESPØNSE R0B7 R0B6 R0B5 R0B4 R0B3 R0B2 R0B1 R0B0

+5V R6 2.2K
1PL-K 100N
1PL-C 101N
1PL-D 102N
1PL-B 103N
1PL-A 104N
1PL-G 106N
1PL-J 106N
1PL-E 107N
1PL-F 108N
R7 R8 R10 R9 R11 R12 R13 R14 R15 R16 47Ω
109 110 111 112 113 114 115 116 117
330PF 0V C7
330PF 0V C9
.001MFD 0V C8 C10 C11 C12 C13 C14 C15
356-2 F6 F5
ACCEPT 2-10
STRØBE 2-4 2-14
ADDRESS 2-3
ADDRESS 2-10
IB5 1-8 1-25
IB4 1-9 1-26
IB3 1-15 1-32
IB2 1-16 1-33 2-3
IB1 1-17 1-35
IB0 1-18 1-36
IB5 2-8
IB4 2-7
IB3 2-6
IB2 2-5

C +5V R17 10K
132
0S 321-2 (60 MS) B7
3.8V D1
0V
C6 .22 MFD
318-9 0C B4
R18 10K
+5V R19 2.7K
C4 0V .001MFD
CLEAR 2-7 2-12 2-18 2-29 2-33 2-36 3-21 3-32

WRITEPLS 2-21
0V
1-18 1-21 IB5 IB4
1-25 1-29 1-32 1-35 IB3 IB2 IB1 IB0
168
D1 D2 D3 D4
R/WEN S1 S2 S4 S8 EN
664-1 16 X 4 RAM
F1 F4 F2 F3
MAD1 MAD2 MAD4 MAD8 MAD16
01 02 03 04 0C
NC NC
137 138 139 140 141 142

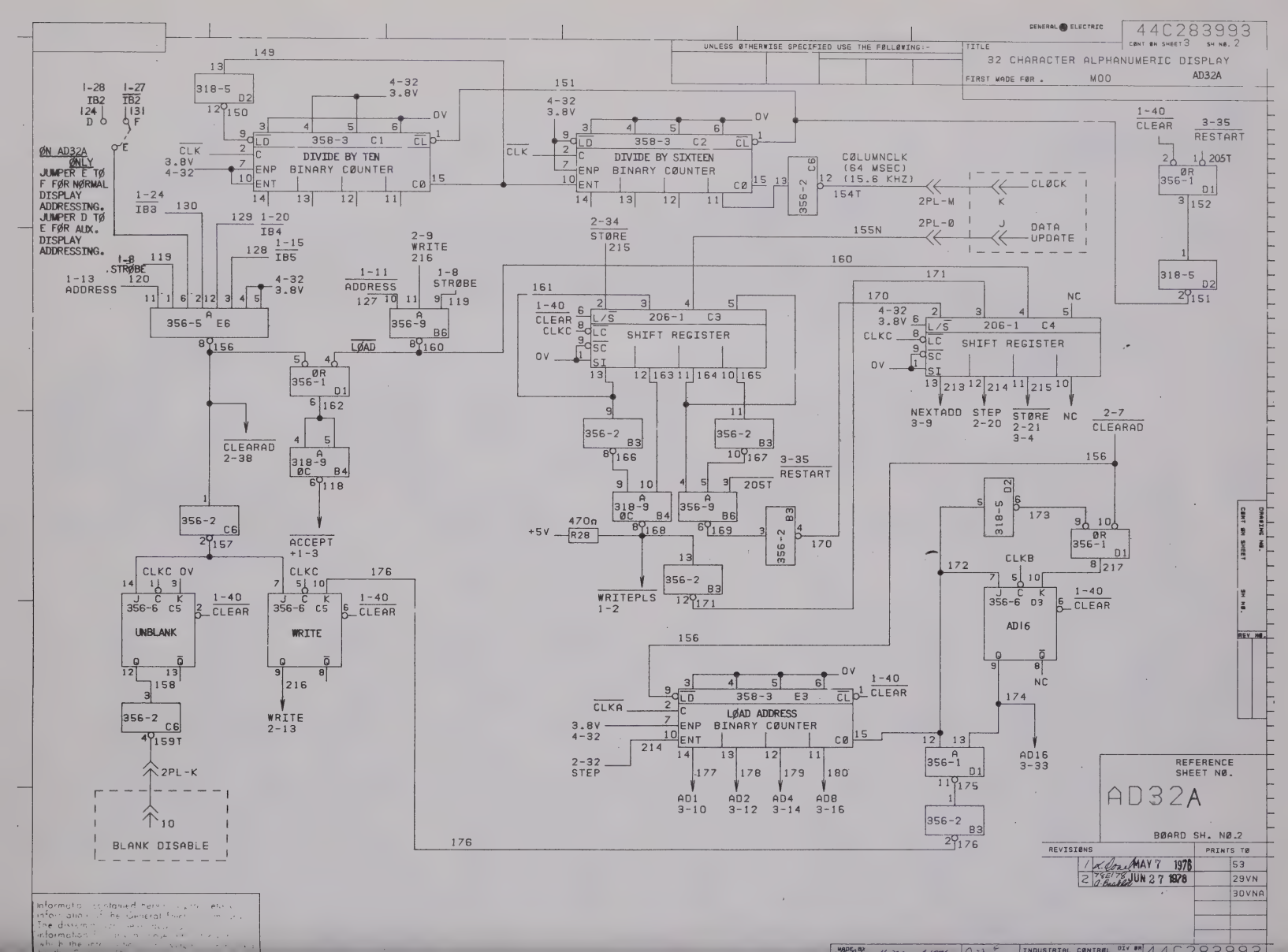
ALL RESISTØRS 1/4 W UNLESS
ØTHERWISE SPECIFIED

R20 R21 R22 R23 R24 R25 2.7K +5V
356-2 E5
B32 3-9
B16 3-11
B8 3-12
B4 3-14
B2 3-21
B1 3-23

REFERENCE SHEET NØ.
AD32A
BØARD SH. NØ.1

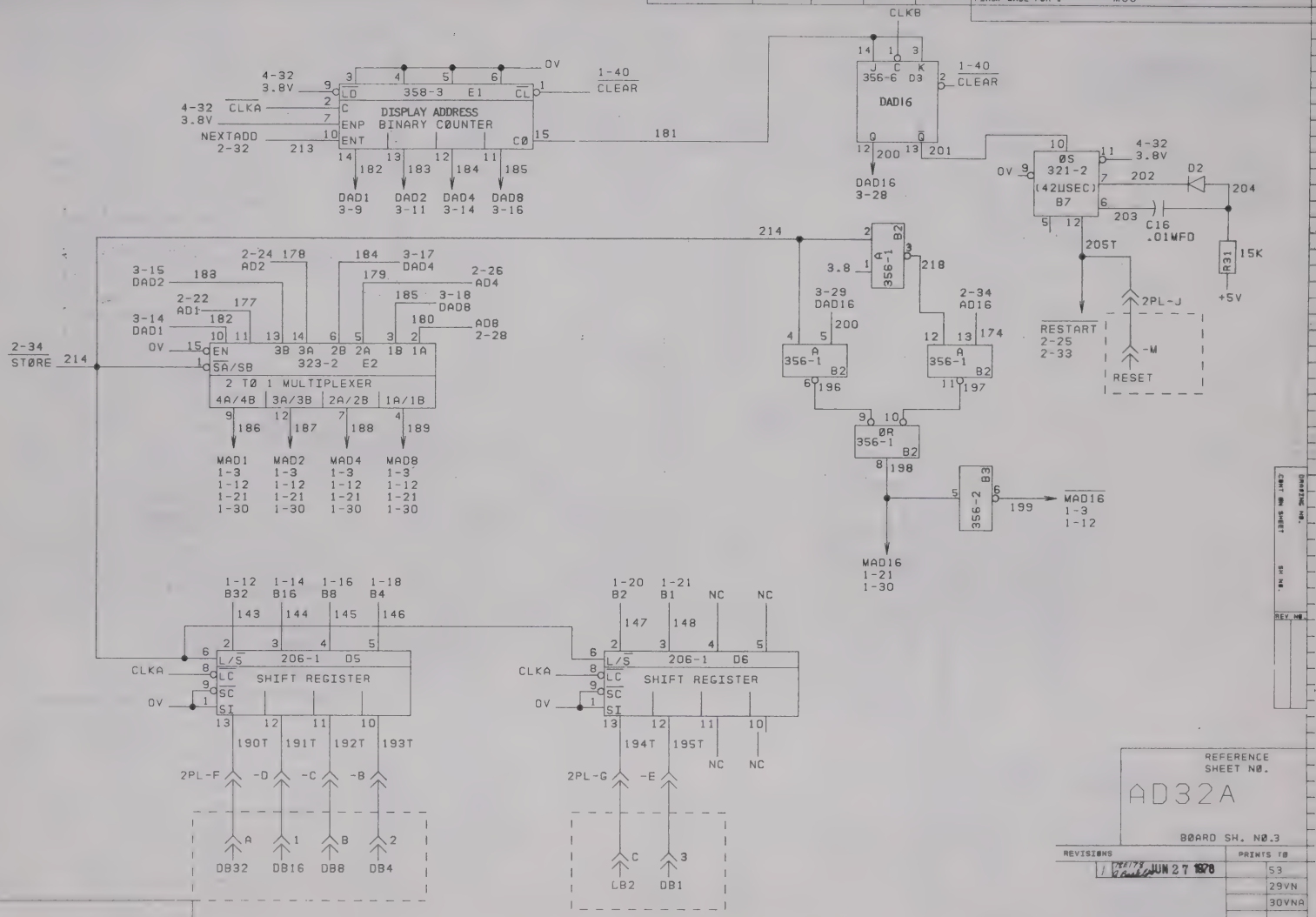
REVISIONS
1 7DEC78 A. Bailey JUN 27 1978
PRINTS TØ
53
29VN
30VNA

MADE BY R. E. Bauer Mar 4 1976
ISSUED APR 23 1976
C.S.C. 4/23/76
INDUSTRIAL CONTROL DIV DEPT
WAYNESBØRØ, VA.
44C283993
CONT ØN SHEET 2 SH NØ.1


GENERAL ELECTRIC
44C283993
CONT ON SHEET 3 SH NO. 2
UNLESS OTHERWISE SPECIFIED USE THE FOLLOWING:-
TITLE
32 CHARACTER ALPHANUMERIC DISPLAY
FIRST MADE FOR . M00 AD32A
ØN AD32A ONLY JUMPER E TØ F FØR NØRMAL DISPLAY ADDRESSING. JUMPER D TØ E FØR ALTX. DISPLAY ADDRESSING.
318-5 D2
4-32 3.8V
DV
CLK
DIVIDE BY TEN BINARY CØUNTER
358-3 C1
DIVIDE BY SIXTEEN BINARY CØUNTER
358-3 C2
CØLUMNCLK (64 MSEC) (15.6 KHZ)
356-2 C6
2PL-M
2PL-Ø
CLØCK
DATA UPDATE
1-40 CLEAR
3-35 RESTART
205T
356-1 D1
2-34 STØRE 215
155N
160
171
170
206-1 C4
SHIFT REGISTER
NEXTADD 3-9
STEP 2-20
STØRE 2-21 3-4
NC
2-7 CLEARAD
156
1-24 IB3
1-20 IB4
1-15 IB5
1-8 STRØBE
1-13 ADDRESS
356-5 E6
LØAD
2-9 WRITE 216
1-11 ADDRESS
356-9 B6
161
206-1 C3
356-2 B3
3-35 RESTART
318-9 ØC B4
356-9 B6
470Ω R28
+5V
WRITEPLS 1-2
CLEARAD 2-38
ACCEPT +1-3
CLKC OV
CLKB
356-6 CS
UNBLANK
WRITE
ADI6
356-6 D3
BLANK DISABLE
2PL-K
LØAD ADDRESS BINARY CØUNTER
358-3 E3
CLKA
2-32 STEP
AD1 3-10
AD2 3-12
AD4 3-14
AD8 3-16
AD16 3-33
REFERENCE SHEET NØ.
AD32A
BØARD SH. NØ.2
REVISIONS
PRINTS TØ
1 MAY 7 1976
2 JUN 27 1978
53
29VN
30VNA
INDUSTRIAL CONTROL DIV 44C283993

32 CHARACTER ALPHANUMERIC DISPLAY AD32

FIRST WADE FØR . M00



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AD32A

BØARD SH. NØ.3

REVISIONS	PRINTS TØ
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	29VN
	30VNA

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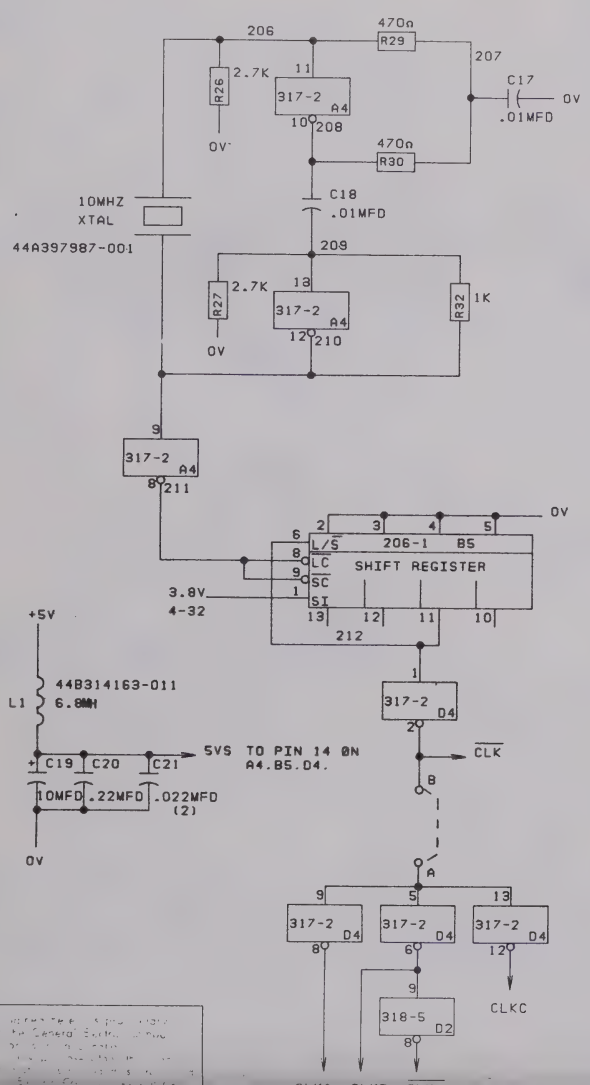

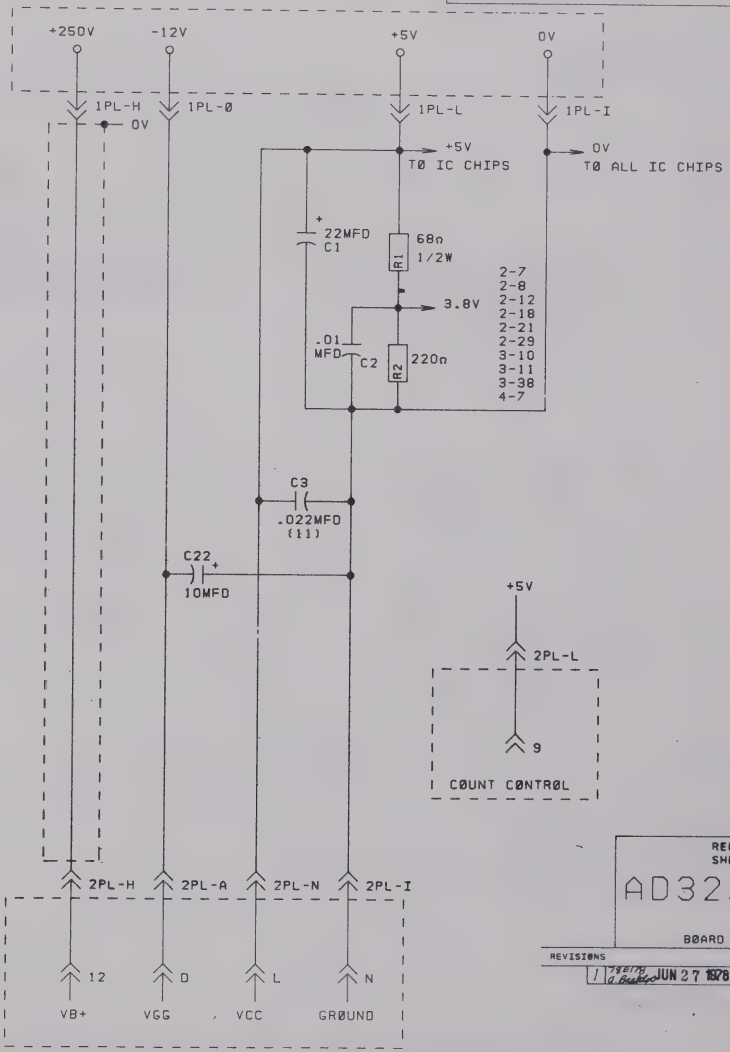

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MODEL NO.

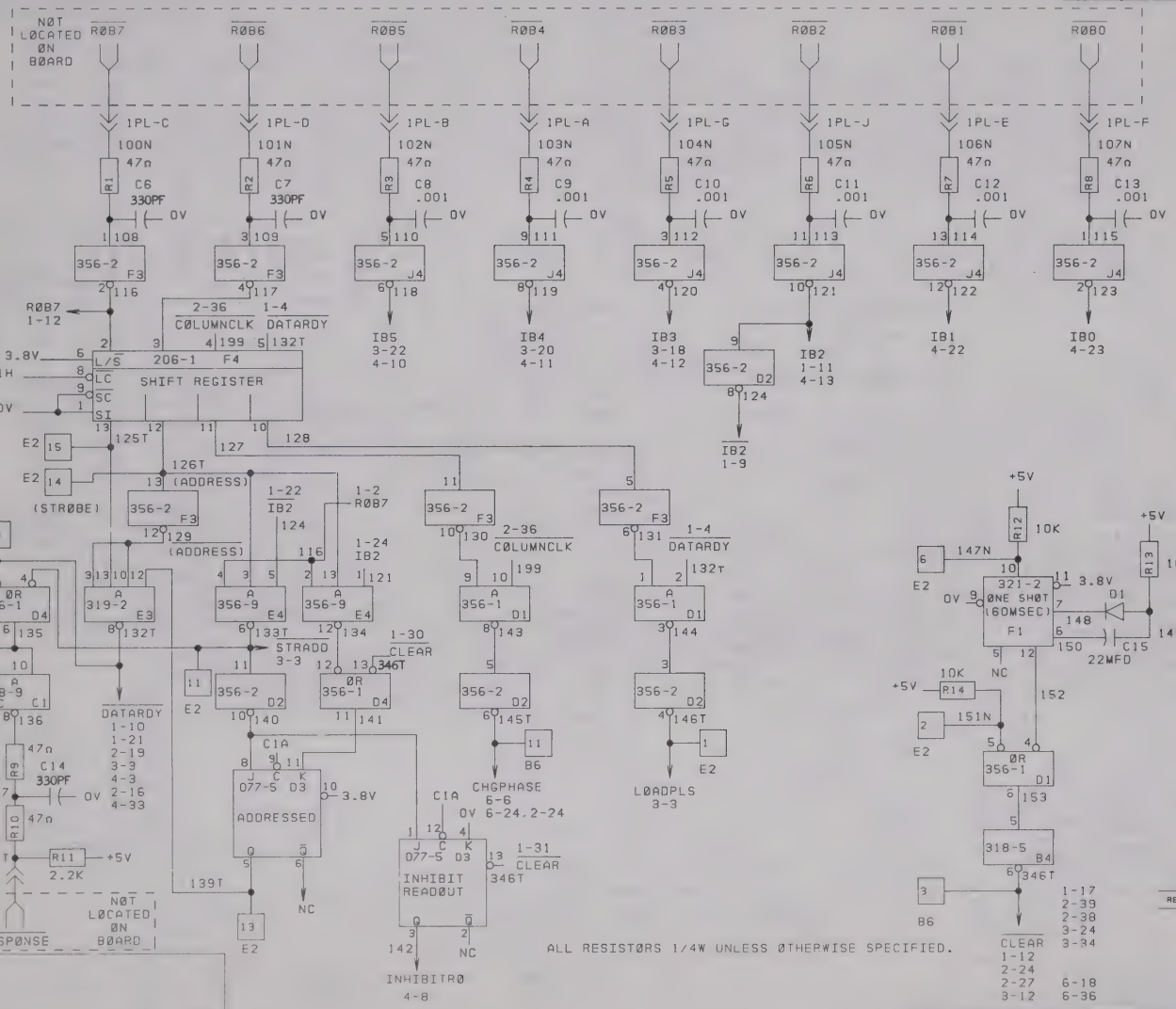
INDUSTRIAL CONTROL DIV

44C283993

256 CHARACTER READOUT BOARD AD256B

FIRST MADE FOR 1050T MOS

R4/MO4 , R5/MO5



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AD256B

BØARD SH. NØ.1

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2		FEB 13 1976	29VNA
1		JUL 2 8 1976	30VNA
0		MAR 2 1 1978	
5		JUL 18 1978	

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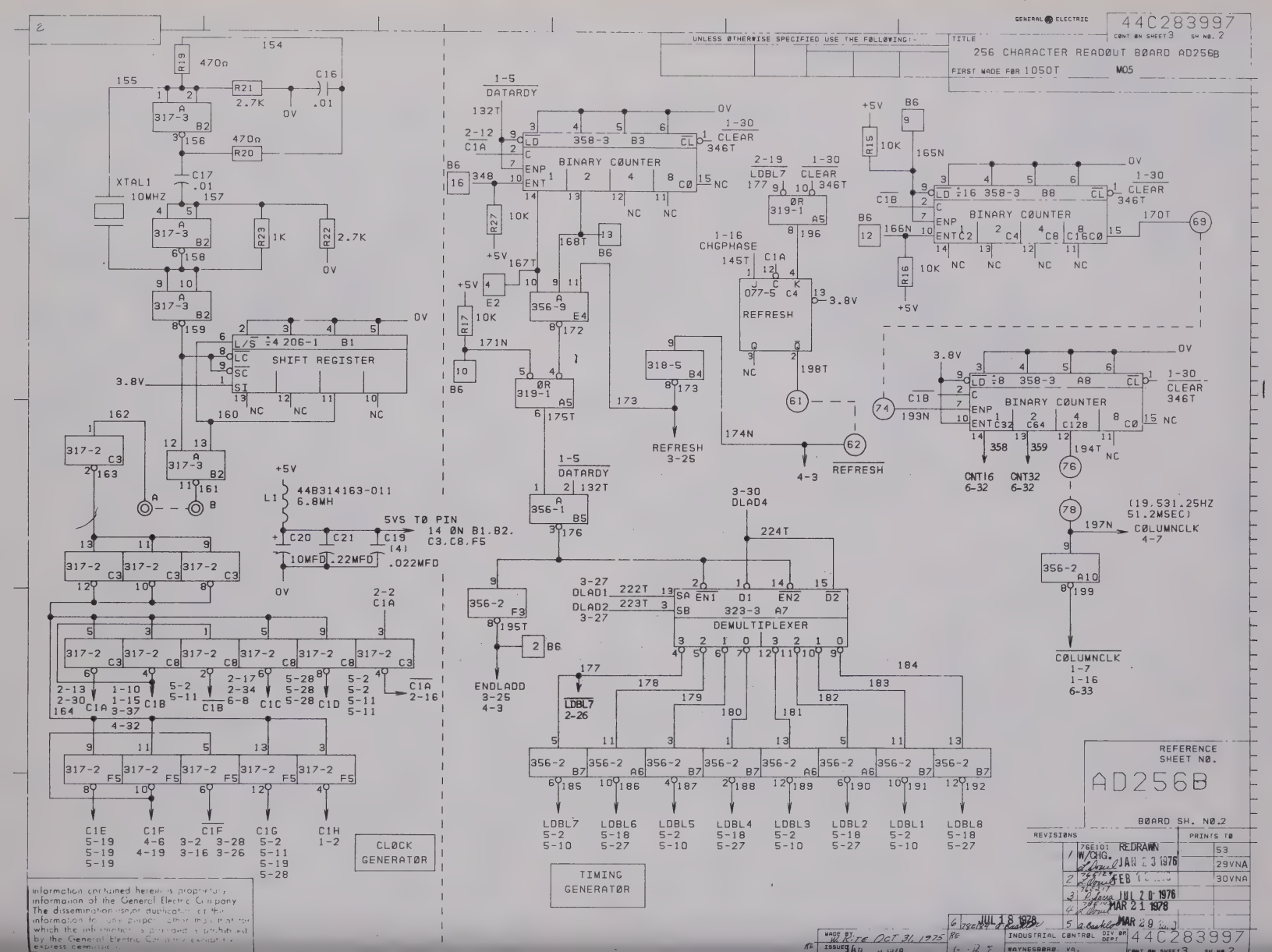
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44C283997
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SH NO. 2
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256 CHARACTER READOUT BOARD AD256B
FIRST MADE FOR 1050T
MOS
154
155
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157
158
159
160
161
162
163
164
R19 470Ω
R21 2.7K
C16 .01
R20 470Ω
C17 .01
XTAL1 10MHZ
R23 1K
R22 2.7K
317-3 B2
317-2 C3
317-2 F5
L/S ÷4 206-1 B1
SHIFT REGISTER
SC
SI
LC
NC
0V
3.8V
+5V
L1 44B314163-011 6.8MH
C20 10MFD
C21 .22MFD
C19 (4) .022MFD
5VS TØ PIN 14 ØN B1.B2. C3.C8.F5
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132T
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358-3 B3
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ENT
CØ
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198T
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62
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R15 10K
R16 10K
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÷8 358-3 A8
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358
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PRINTS TØ
76E101 REDRAWN W/CHG.
JAN 23 1976
FEB 1 1976
JUL 20 1976
MAR 21 1976
MAR 29 1976
JUL 18 1978
53
29VNA
30VNA
MADE BY
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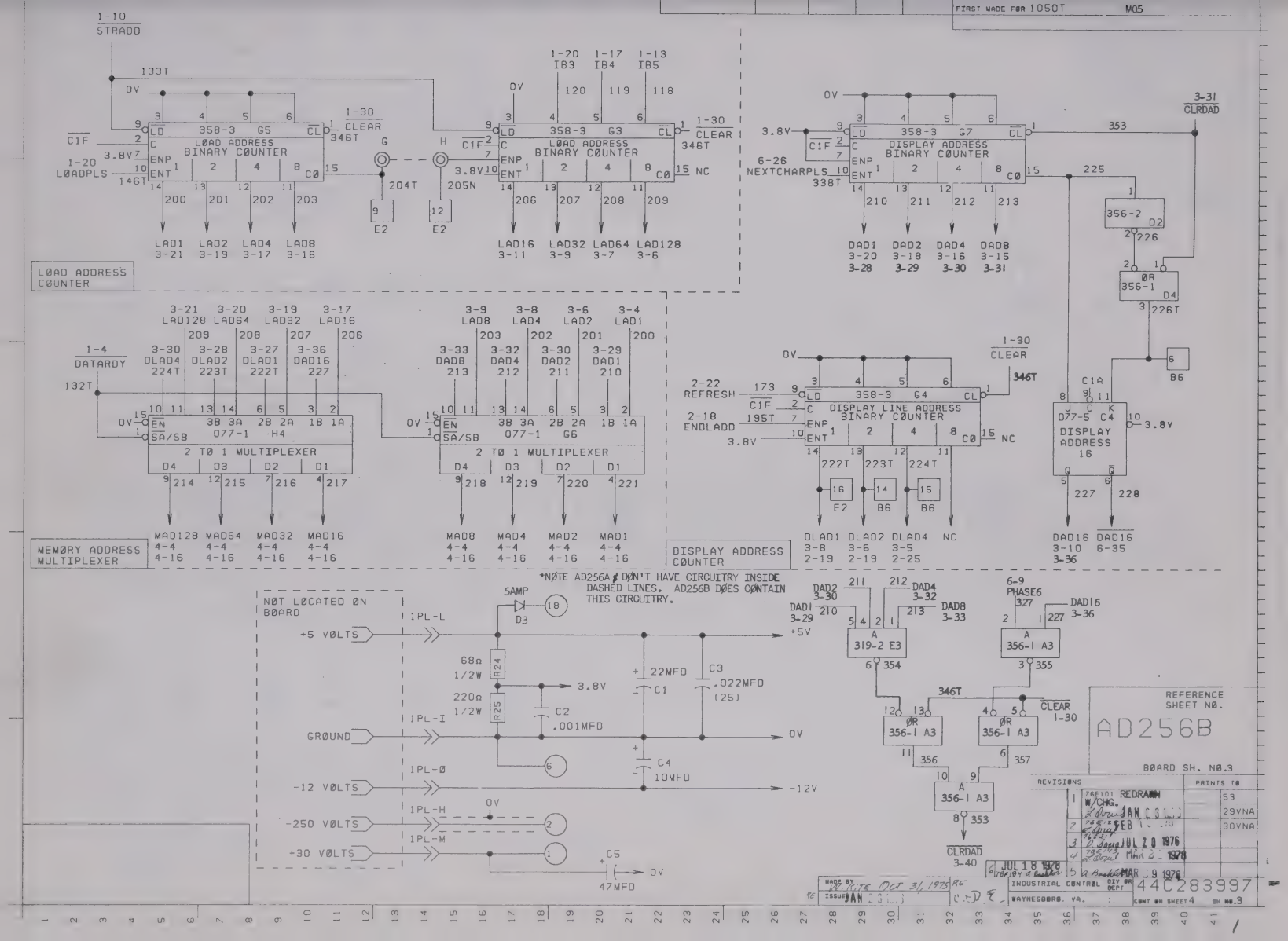
1-10 STRADD
133T
0V
1-30 CLEAR
346T
C1F
LØAD ADDRESS BINARY CØUNTER
3.8V
1-20 LØADPLS
146T
ENP
ENT
CØ
200 201 202 203
LAD1 3-21
LAD2 3-19
LAD4 3-17
LAD8 3-16
204T
E2
205N
1-20 IB3
1-17 IB4
1-13 IB5
120 119 118
206 207 208 209
LAD16 3-11
LAD32 3-9
LAD64 3-7
LAD128 3-6
NC
LØAD ADDRESS CØUNTER
3-31 CLRDAD
353
DISPLAY ADDRESS BINARY CØUNTER
6-26 NEXTCHARPLS
338T
210 211 212 213
DAD1 3-20 3-28
DAD2 3-18 3-29
DAD4 3-16 3-30
DAD8 3-15 3-31
225
356-2 D2
226
ØR 356-1 D4
226T
B6
1-4 DATARDY
132T
3-21 LAD128
3-20 LAD64
3-19 LAD32
3-17 LAD16
209 208 207 206
3-30 DLAD4 224T
3-28 DLAD2 223T
3-27 DLAD1 222T
3-36 DAD16 227
EN
SA/SB
3B 3A 2B 2A 1B 1A
077-1 H4
2 TØ 1 MULTIPLEXER
D4 D3 D2 D1
214 215 216 217
MAD128 MAD64 MAD32 MAD16
4-4 4-16
3-9 LAD8
3-8 LAD4
3-6 LAD2
3-4 LAD1
203 202 201 200
3-33 DAD8 213
3-32 DAD4 212
3-30 DAD2 211
3-29 DAD1 210
077-1 G6
218 219 220 221
MAD8 MAD4 MAD2 MAD1
MEMØRY ADDRESS MULTIPLEXER
2-22 REFRESH
173
2-18 ENDLADD
195T
DISPLAY LINE ADDRESS BINARY CØUNTER
222T 223T 224T
DLAD1 3-8 2-19
DLAD2 3-6 2-19
DLAD4 3-5 2-25
DISPLAY ADDRESS CØUNTER
C1A
077-5 C4
DISPLAY ADDRESS 16
227 228
DAD16 3-10 3-36
DAD16 6-35
*NØTE AD256A DØN'T HAVE CIRCUITRY INSIDE DASHED LINES. AD256B DØES CØNTAIN THIS CIRCUITRY.
NØT LØCATED ØN BØARD
+5 VØLTS
GRØUND
-12 VØLTS
-250 VØLTS
+30 VØLTS
1PL-L
1PL-I
1PL-Ø
1PL-H
1PL-M
5AMP
D3
68Ω 1/2W R24
220Ω 1/2W R25
C1 22MFD
C2 .001MFD
C3 .022MFD (25)
C4 10MFD
C5 47MFD
DAD2 3-30
DAD1 3-29
DAD4 3-32
DAD8 3-33
DAD16 3-36
6-9 PHASE6
319-2 E3
356-1 A3
+5V
-12V
CLRDAD 3-40
REFERENCE SHEET NØ.
AD256B
BØARD SH. NØ.3
REVISIONS
PRINTS TØ
W/CHG.
53
29VNA
30VNA
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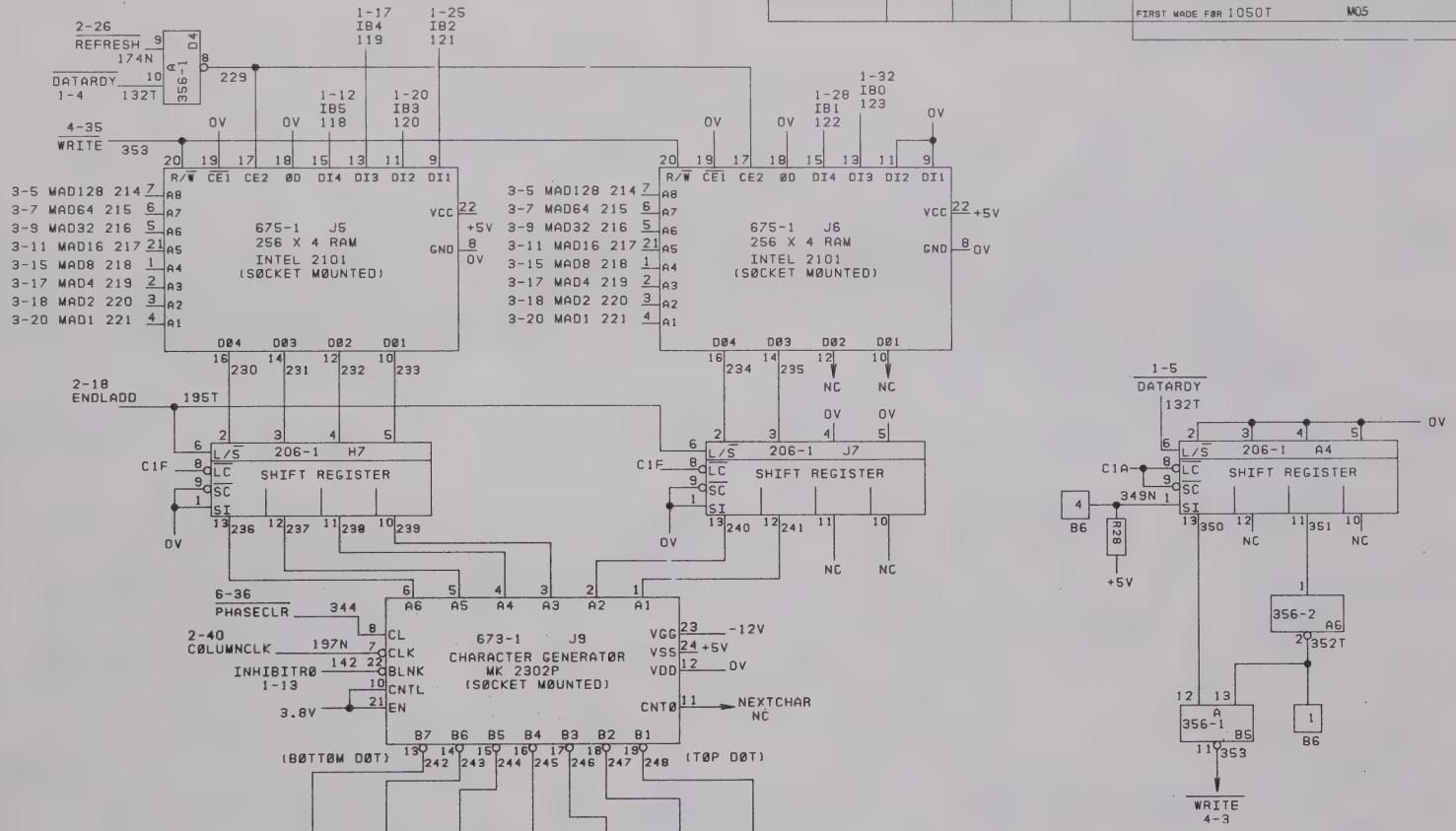

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AD256B
BOARD SH. NO.4

REVISIONS			PRINTS TO
	76E101	REDRAWN	53
1		WITH CHG JAN 23 1976	29VN
2	76E12	JAN 23 1976	30VNA
3	76E17	JUL 20 1976	
4	76E175	MAR 31 1978	
5	76E176	JUL 18 1978	

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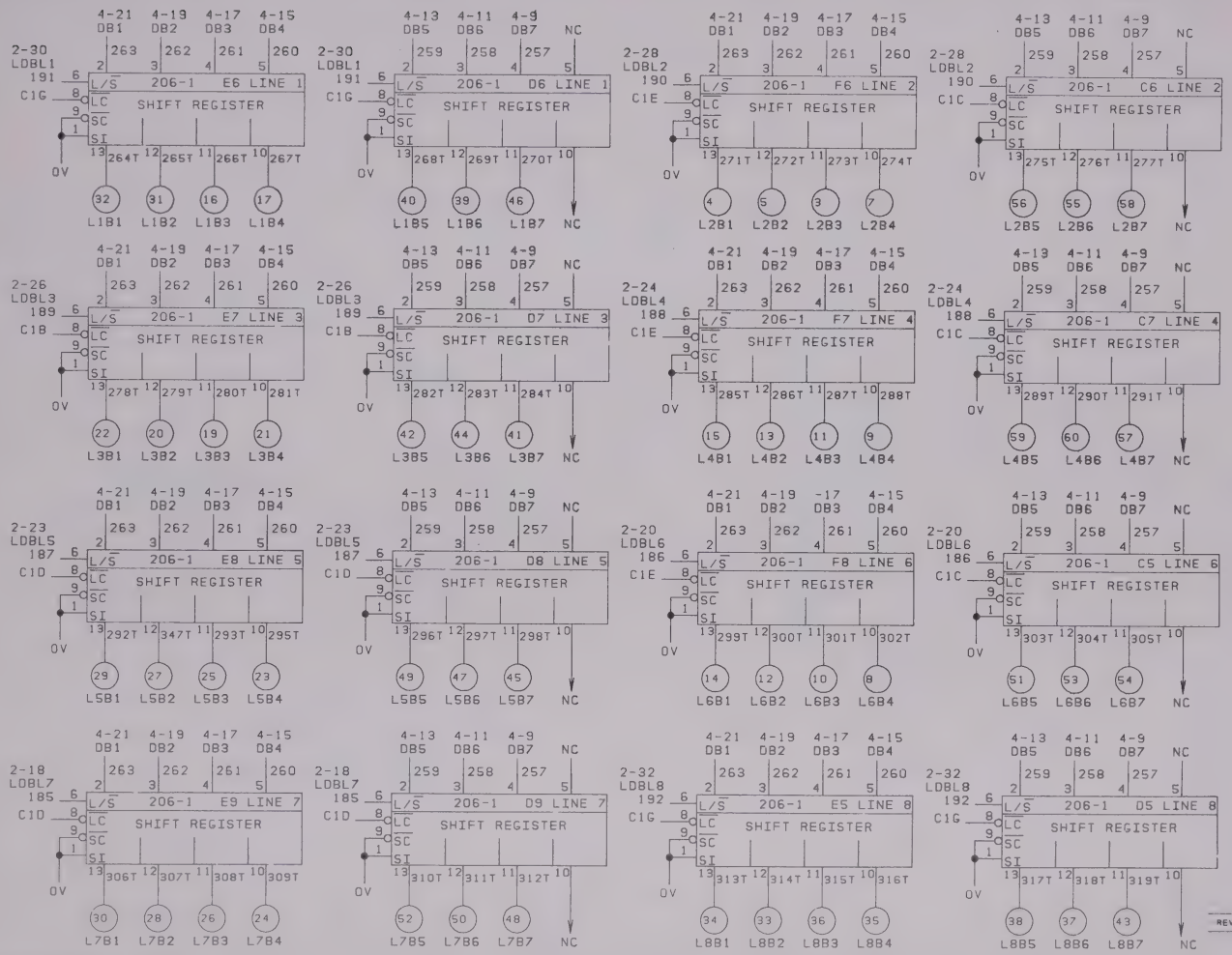

256 CHARACTER READOUT BD. (AD256B)

FIRST MADE FØR 1050T

REFERENCE SHEET NØ.

AD256B

BØARD SH. NØ.5

REVISIONS		PRINTS TØ
1	76E101 REDRAWN WITH CHG JAN 23 1976	53
2	JAN 29 1976	29VN
3	JUL 20 1976	30VNA
4	MAR 6 1978	
5	JUL 18 1978	

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INDUSTRIAL CONTRØL DIV. ØF DEPT. WAYNESBØRØ, VA.

44C283997

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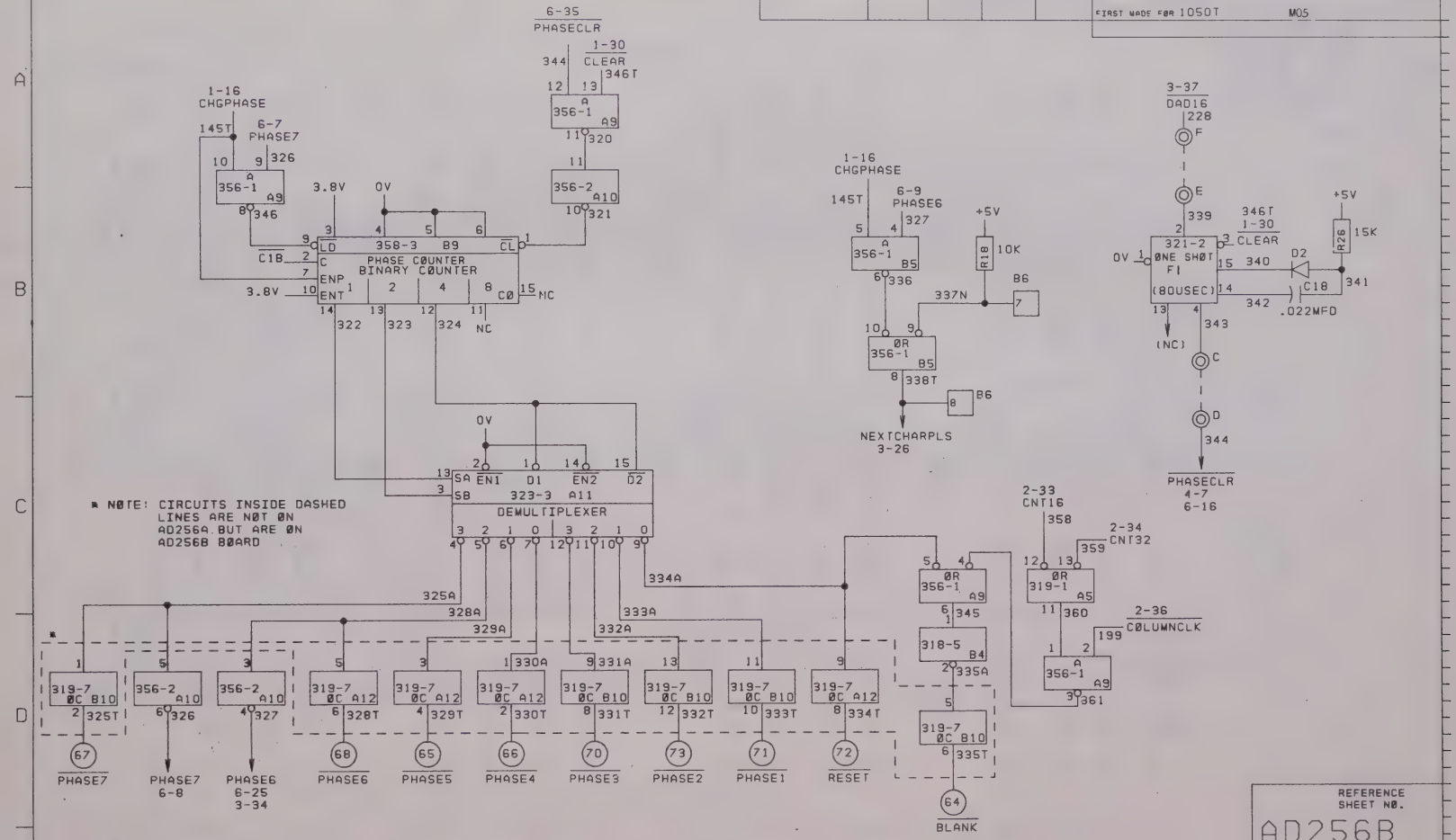
FIRST MADE FOR 1050T MOS



CATHODE
PHASE GENERATOR

REFERENCE SHEET NO.
AD256B

BOARD SH. NO. 6

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4	ZBE143 REDRAWN WITH CHANGES BY [illegible]	MAR 21 1978	53
5	[illegible]	MAR 29 1978	29VNA
6	[illegible]	JUL 18 1978	30VNA

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CHAPTER XI
TAPE READER

GEK-45650A

INSTRUCTIONS

MARK CENTURY

150-CPS TAPE READER

ASSEMBLY NUMBER 44D232560-G01

AND

150-CPS TAPE READER/REELER

ASSEMBLY NUMBER 3N3200TR103B1

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Industrial Control Department • General Electric Company

Waynesboro, Virginia 22980

GENERAL ELECTRIC

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AUGUST, 1977

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SECTION 1
DESCRIPTION OF EQUIPMENT

1.1. GENERAL DESCRIPTION

This instruction book covers the 150-CPS Tape Reader and the 150-CPS Tape Reader with integral Reeler. Each reader is assembled on a one-piece, rack-mounted panel. The Reader portion of this book applies to both type readers while the Reeler portion applies to the reeler.

Both readers are manufactured by the Industrial Control Department of General Electric Company, Waynesboro, Virginia, U.S.A. The readers are designed to be used with Mark Century* Controls.

This book contains the following sections: General Description, Specifications, Installation, Theory of Operation, Operation, Checks and Adjustments, Preventive Maintenance, Troubleshooting, Parts Removal and Replacement, Parts Lists, and Drawings.

The Reader (Figure 1.1.) reads bidirectionally. It is designed to operate with 1-inch perforated tape in loops or strips. The Reader/Reeler (Figure 1.2.) also reads bidirectionally. It is designed to operate with 1-inch perforated tape in loops or strips. In addition, it operates with tape from reels. The reeler supplies and takes up tape bidirectionally as the tape reader commands.

The reader consists of a lamp-lens photosensor system, tape guides, and a sprocket drive wheel for tape transport. Tape is read at a rate of 150 characters per second. The electrical outputs of the silicon photosensors are amplified by circuitry which is not a part of the reader. Also, the drive signals to the stepping motor come from circuits which are not a part of the reader.

The reeler is self-contained. It operates to supply and take up tape as the reader demands. The reel shafts are 1/2 inch diameter and accept standard** plastic reels of outside diameter up to 7 1/2".

In the reader/reeler, the tape is rewound by operating the reader to drive the tape from right to left. Since the reeler is bidirectional it automatically follows the reader. Hence, the tape is rewound without special circuits in the reeler. Depending on options in the Control, the tape may rewind at speeds of either 150 CPS or 250 CPS or both. Normally the Control option will call for continuous rewind at 250 CPS and, in addition, may also have a Block-by-Block rewind at 150 CPS.

Additional information covering performance as well as operating, electrical and physical characteristics is provided in Section 2, "Specifications".

1.2. INTERCHANGEABILITY

No changes have been incorporated in the 44D232560-G01 Reader. The 3N3200TR103B1 Reader/Reeler has been designed to be interchangeable with the 3N3200-TR103A1 and 44C394200-G01 Reader/Reelers.

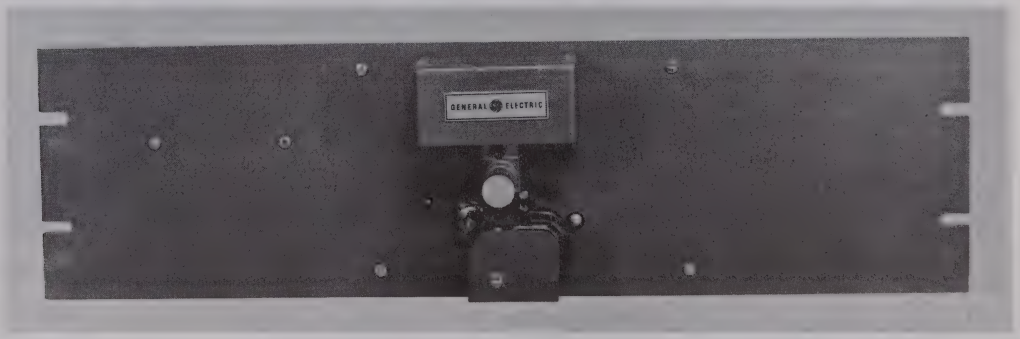

Figure 1.1.
READER (ASSEMBLY NUMBER 44D232560-G01)

* Trademark of General Electric Company, USA
** USASI Standard USAS x 3.20 - 1967

Figure 1.2.
READER/REELER (ASSEMBLY NUMBER 3N3200TR103B1)

SECTION 2
SPECIFICATIONS
READER
(ASSEMBLY NUMBER 44D232560-G01)

Specifications of the 150-CPS Tape Reader are provided below.

TABLE 2.1.

Feed direction	bidirectional - forward read direction is left to right
Read speed	150 characters per second nominal ±10% forward and rewind (controlled by external P.C. Board)
Rewind speed	250 characters per second (controlled by external P.C. Board)
Tape:	
Width	1 inch (8 channel plus sprocket)
Thickness	0.0037 inch
Splices	Butt spliced to 0.010" thick
Opacity	90 to 100%
Type	Mylar - aluminum laminate - 10000 passes black paper - 100 passes
Temperature	0 to 65°C
Dimensions:	
Height	5 1/4 inches
Width	19 inches
Depth	3 1/2 inches (from the mounting surface to the back of the unit) 2 11/16 inches (from the mounting surface forward)
Weight	5 pounds
Power Requirements:	
Motor voltage	24 VDC ±2%
Power load (motor)	25 watts
Lamp voltage	12 VDC ±2%
Power load (lamp and resistor)	33 watts

READER/REELER
(ASSEMBLY NUMBER 3N3200TR103B1)

Specifications for the 150-CPS Reader/Reeler are provided below.

TABLE 2.2.

Feed direction	bidirectional - forward read direction is left to right
Read speed	150 characters per second nominal ±10% forward and rewind (controlled by external P.C. Board)
Rewind speed	250 characters per second (controlled by external P.C. Board)

Tape:	
Width	1 inch (8 channel plus sprocket)
Thickness	0.0037 inch
Splices	Butt spliced to 0.010" thick
Opacity	90 to 100%
Type	Mylar - aluminum laminate - 3000 to 5000 passes black paper - 30 to 50 passes
Reels:	
Size	7 1/2" outside diameter, 1/2" inside diameter
Capacity	800 feet per reel
Type	The recommended reel for use with the reeler is G. E. No. 44A393691-001 (black Noryl material) as supplied. This reel is the only one which should be used on the right reeler for satisfactory life. It is best to use the recommended reel on the left reeler; however, reels of different design may be used with a reasonable life expectancy. Reels of other design than the recommended reel may, under some conditions, tend to form a powder of the base material due to relative motion among parts of the reel. This powder, if observed, should be removed to prevent eventual migration into the read area which might lead to reading errors.
Dimensions:	
Height	10 15/32"
Width	19"
Depth	7 11/16" (from the mounting surface to the back of the unit) 2 13/16" (from the mounting surface forward)
Weight	42 pounds
Temperature	0 to 65°C
Power Requirements:	
Reader:	
Motor Voltage	24 VDC ±2%
Power load (motor)	25 watts
Lamp voltage	12 VDC ±2%
Power load (lamp and resistor)	33 watts
Reeler:	
Input voltage	115 VAC ±10%, 47 to 63 Hz
Fuse (F1)	1 amp slow blow
Power Load (AC only)	50 watts
Total Power Dissipation (Reader and Reeler)	107 watts maximum

SECTION 3
INSTALLATION

3.1. UNPACKING

Normally the Tape Reader unit is shipped assembled and mounted in the Control. If it is necessary to remove the reader from the Control, grasp the reader by the front panel. DO NOT USE THE MOTOR OR OTHER COMPONENTS AS LIFTING FIXTURES.

3.2. REPLACEMENT READERS

A replacement tape reader is shipped assembled and packed in a shipping carton so that it will not be damaged in transit. The tape reader should be removed from the carton as follows: Remove the top layer of protective material. Then remove the unit by lifting it clear of the carton. Grasp the reader by the front panel. DO NOT USE THE TENSION ARMS OR REEL HUBS AS LIFTING FIXTURES. After you have removed the unit from the shipping carton, carefully remove the ties or rubber bands used to constrain the tension arms during shipment.

Listed below are shipping cartons which have been specially designed for shipping readers and reader/reelers.

Reader - Shipping carton R-950 - Rev. 1 with packing instructions contained in GEK-45548
Reader/Reeler - Shipping carton R-900 - Rev. 1 with packing instruction contained in GEK-45547

3.3. INSTALLATION CHECKS

Prior to installation, the Reader should be given a visual inspection for signs of damage that may have occurred in transit (Table 3.1. provides a convenient guide for this inspection). If any apparent damage exists as a result of shipping, it should be reported to the carrier immediately. The General Electric Company should also be notified.

TABLE 3.1.
VISUAL CHECK FOR SIGNS OF DAMAGE

ITEM	CHECK
Reader tape transport	All components are tightly secured to the front panel, there is no evidence of damage, and general alignment is obviously correct.
Lamp	The bulb is secured in the socket, and there is no visible damage.
Electrical Wiring	There is visible continuity, and there are no broken or damaged wires.
Electrical Components	Terminal boards and resistors are not broken. There is no evidence of overheat.
Motors	Each motor is securely mounted, the shafts rotate with power removed, electrical wiring is visibly secure, and the motor cases are intact.
Fuse (Reader/Reeler Only)	The fuse receptacle is tightly secured to the panel, electrical connections are intact, the fuse is properly seated and is of the correct value.
Front Panel Reader/Reeler (Reader/Reeler Only)	Control switches are secured to the panel, the toggle and tape break switches are intact, mechanical operation is evident, and markings are legible.
Tape Tension Arms (Reader/Reeler Only)	Arms move smoothly against the spring tension when they are displaced from broken tape (inner stops); there is no visible evidence of damage, the arms do not scrape the panel, there is full excursion by the arms to the outer limits without binding, and the arms snap into the clips properly. The rollers rotate freely.
Ganged Rollers (Reader/Reeler Only)	Check that assembly or individual rollers are not bent out of position.

3.4. MOUNTING INSTRUCTIONS

The unit is designed for fixed mounting on a standard, 19-inch, vertical equipment rack.

To insure adequate ventilation, be sure there are no obstructions around the reader motor or the reeler motors.

The unit should be mounted as follows: Position the unit on the rack, and secure it with four 10-32 pan-head screws fed through the front panel slots. When the unit has been inspected and installed, it should be connected to the Control.

3.5. POWER REQUIREMENTS

Reader

Motor power is supplied in the form of pulses (approximately 24 volts) from the tape reader drive board and is introduced through terminal board TB2. Lamp power, 12 VDC, is supplied through TB2. The voltage is dropped through a series resistor and is then applied to the lamp. (See Table 3.2.).

Reader/Reeler

The reader portion receives power the same way as the reader. See the paragraph above. Primary power (115 VAC) for the reeler portion of the unit is applied through terminal board TB3. Connections for the load switch interlock and the broken tape interlock are located on TB3.

3.6. INTERFACE DATA

The Reader/Control interface for the Reader is located on two terminal boards as shown in Table 3.2. The interface for the Reader/Reeler is on three terminal boards as shown in Tables 3.2. and 3.3.

TABLE 3.2.
READER/CONTROL INTERFACE

SOLAR CELL OUTPUT-TERMINAL BOARD TB1			
PIN	UTILIZATION	PIN	UTILIZATION
A	Track 1	J	Sprocket
B	Track 2	K	Cell Common
C	Track 3		
D	Track 4		
E	Track 5		
F	Track 6		
G	Track 7		
H	Track 8		

READER POWER/CONTROL-TERMINAL BOARD TB2			
PIN	UTILIZATION	PIN	UTILIZATION
A	Reader-Chassis Ground	H	Phase 2, Motor
	Reader/Reeler-Solar Cell	J	Phase 3, Motor
	Assem Shield	K	Motor Common, + 12V
B	Lamp Common, 0V		
C	Lamp +12V		
D	Not Used		
E	Not Used		
F	Not Used		
G	Phase 1, Motor		

TABLE 3.3.
REELER/CONTROL INTERFACE

REELER POWER/CONTROL-TERMINAL BOARD TB3			
PIN	UTILIZATION	PIN	UTILIZATION
A	Run/Load Switch (NC)*	F	Not Used
B	Run/Load Switch (NO)*	G	Not Used
C	Run/Load Switch (Common)	H	Chassis Ground
D	Broken Tape Interlock	J	115V AC (Neutral)
E	Broken Tape Interlock	K	115V AC

*Shown with Run/Load switch in the RUN position.

SECTION 4
THEORY OF OPERATION

This section is divided into two parts: The Reader Section and the Reeler Section.

READER SECTION

4.1. GENERAL INFORMATION

The Tape Reader is a bidirectional tape reading device that operates with tape loops or strips. Reading is accomplished photoelectrically at the read head. The electrical outputs of the silicon photosensor that represent the digital tape data are amplified by circuitry that is not physically a part of the reader. An electrically pulsed stepping motor controls tape motion through the read head. The command signals used to operate the stepping motor come from the Control, and they are connected to the reader at terminal board TB2.

NOTE: When the Reader/Reeler is used in the Loop mode (running loops or strips of tape without employing reels), both reeler arms must be resting on the rubber bumper stops or both must be retained in the load clips. This disables both reeler motors and prevents a broken tape output to the Control. If one arm is on the stop and the other retained in the clip, the reelers are disabled but a broken tape output is input to the Control.

4.2. DRIVE SYSTEM

The tape is advanced incrementally by means of a toothed sprocket wheel driven by a three-phase servo stepping motor. The sprocket drive wheel is attached directly to the stepping motor shaft. There are no gears or belts associated with this unit.

Pulses from an SCR ring counter which is located in the Numerical Control drive the motor. When the pulses from the ring counter energize the motor windings in a 1-2-3 phase sequence, the motor rotates clockwise and drives the tape in the forward read direction (left to right). When the pulses energize the motor windings in a 3-2-1 phase sequence, the motor rotates counterclockwise and drives the tape in the reverse direction (right to left). The tape advances one character for each input pulse to the motor.

When the tape is commanded to stop, the SCR ring counter stops counting, and the motor winding which was last energized remains energized causing the motor to stop on a magnetic detent. The motor action of stopping on a magnetic detent causes the tape to stop on a character eliminating the need for a brake.

When the power is initially turned on during a Control start-up sequence, the stepping motor may step forward or backward one position causing the tape to move forward or backward one character. This is characteristic of the SCR drive circuits in the Control. A description of the operation of the drive circuits used in conjunction with this reader is found in a separate General Electric Company publication, GEK-29707.

4.3. PHOTOELECTRIC READ HEAD

The photoelectric read head consists of a light source, lens assembly, and photosensor. The light source output is focused by a rod lens into a narrow line which spans the tape at right angles to the tape edge. Light then passes through a hole in the tape, crisscrosses, and finally focuses into a straight line by a convex lens located beneath the tape. The line of light strikes the face of the photosensor which generates a data pulse that is coupled via a terminal board to circuitry in the Control.

4.4. LIGHT SOURCE

The light source is a bayonet-based lamp that operates at less than its rated voltage to insure long life. A resistor (R1) is connected between one side of the lamp and +12 volts. Resistor R1 drops the voltage to obtain the proper voltage; i.e., +9.2 volts.

4.5. LENS ASSEMBLY

The lens assembly consists of a rod lens fixture mounted above the tape. This lens assembly focuses the light into a narrow line that is then passed through the holes in the tape. A mask and single lens assembly are located beneath the tape path. This arrangement is used to focus the light into a straight line prior to its striking the face of the photosensor.

4.6. PHOTOSENSOR ASSEMBLY

The photosensor array is mounted in a molded plastic housing which possesses a self-contained mask with individual apertures for each data channel. The array is a nine-segment silicon unit sealed with a cover glass over which the tape passes. Electrical connections to each segment are made through a terminal board on the rear of the reader. When a hole in the tape appears over any segment of the photosensor, the output of that segment increases sufficiently to trigger the amplifier circuitry (external to the reader) and thereby "read" the hole.

REELER SECTION

4.7. GENERAL INFORMATION

The Reeler section of the Reader/Reeler controls the supply of paper tape as it is stepped through the read head during the reading operation, and it provides for rewind as required. Two separate reel drive motors are directly connected to the reel hubs. These motors are activated as required to (1) insure a smooth transfer of tape to the associated reader and (2) to provide smooth control over tape take-up as the tape leaves the read head. The reel that provides tape to the reader is termed the "supply reel" and the reel that picks up previously read tape is termed the "take-up" reel.

4.8. READER/REELER SYNCHRONIZATION

Reeler operation is automatic in that the unit senses the requirements of the reader as tape is stepped through the read head. The reeler either furnishes tape from the supply reel or it takes up the tape exiting from the reader on the take-up reel. The tension arms on the front panel serve as the sensing elements to provide the desired reader/reeler synchronization. The two tension arms are pivoted, mechanical devices that operate in conjunction with associated motors and reels to maintain a buffer loop of tape. When the tape is properly loaded, it is wound around the tension arm rollers displacing the arms from the spring-loaded Out-Of-Tape position. Each tension arm is mechanically connected to a shaft to which is attached a metal vane. As the arm moves, the shaft turns and each vane moves to permit or interupt the LED light of the two photon interupter devices which provide the proper outputs for driving the RSD3 printed-circuit board. As the arms move in response to the demands of the tape reader, the motors turn on to drive the tape reels in a direction to keep the arms near the center of their travel. To keep power off the motors when the reader is not reading tape, a stop zone is established in the center third of the arm's travel. As the arm moves out of this zone, the circuit turns on current to the motor in such a direction as to drive the arm back into the stop zone.

The two reel motors, the tension arms and feedback assemblies plus the control circuit associated with each motor, comprise two separate closed-loop servo systems. The motors are DC operated with permanent magnet fields.

Motor rotation is initiated by an armature current extracted from the 115 VAC primary source. Each motor armature is driven from the AC line through a transformer, rectifier and two transistors for each motor. The transformer sets the amplitude of the voltage applied to the motors to determine their speed, and the transistors determine the polarity of the DC voltage. The polarity of the resultant armature voltage determines the direction of motor rotation, and the amplitude determines the speed. The detailed means by which armature current is applied to control motor operation is discussed in the paragraphs which follow. Since the two servo systems are identical, only the left-hand system will be described.

4.9. TAPE ARM MOVEMENT ZONES

The movement of the tape arms is divided into five zones which in turn control the operation of the reel

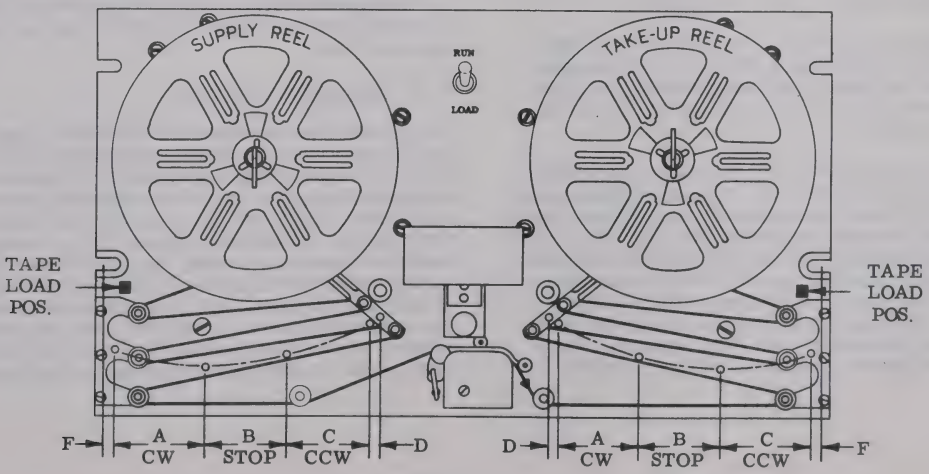

Figure 4.1.
TAPE ARM MOVEMENT AND MOTOR OPERATING ZONES

motor. Figure 4.1. shows the five zones as they apply to the right and left arms. When either arm is in zone A, the corresponding motor runs clockwise to drive the tape so that the arm will move back toward and into zone B. When either arm finds itself in zone C, the motor runs counterclockwise. This will again drive the arm back toward and into zone B. As long as the arm stays in zone B, the stop zone, the motor will not run.

A fourth zone, D, is provided when the arm gets close to the Broken Tape switch and mechanical stop. When the tape breaks, the arms, because of the springs attached to them, move toward the mechanical stops located near the center of the panel. Each arm actuates a Broken Tape switch just before it hits the stop. Actuation of either Broken Tape switch provides an output to the Control that the tape has broken. When either arm is resting on the stop, the corresponding reeler motor is disabled.

A fifth zone, F, is provided to disable the corresponding reeler motor when the tension arm is in the clip which holds the tension arm during tape loading. The tension arms must be released from the clip after tape loading for normal running operation.

When loading tape, the Run/Load switch should be in the LOAD position which disables the reelers. The tension arms are moved to the extreme outward position and are held by arm load clips. With the arms in this position, the reelers are additionally disabled such that if the Run/Load switch is put in the RUN position, uncontrolled unwinding of tape off the reels is prevented.

4.10. Photo-Detector and Motor Drive

A simplified block diagram for a single reel motor drive servo is shown in Figure 4.2. The principal parts are the shutter, the photon interrupters, the direction amplifiers, the transistor drive, and the motor circuits.

Two photon interrupters are mounted on each RSF1 printed-circuit board located in each feedback assembly. The printed-circuit board is so positioned that the shutter is within the photon interrupter slot. The shutter slot in turn permits or blocks the LED light to the photo transistor sensor of the photon interrupter. The shutter is attached to the feedback assembly shaft and its position is determined by the position of the tension arm. The output from the photon interrupter transistors drives the RSD3 printed-circuit board which contains all the circuitry for driving both reel motors in each direction. Refer to Figure 11.3. for the complete circuitry.

The RSD3 printed-circuit board contains four nearly identical circuits for driving the two reel motors in each direction (Figure 11.3.). There is also a D.C. supply for powering the LED diodes of the photon interrupters. The circuit description for one of the four circuits is as follows. When light is blocked in the photon interrupter, upper PI-1 transistor is off which allows Q9 to turn on. This causes Q1 and Q5 to be off, resulting in no motor current flow. When the tension arm moves so that PI-1 is exposed to light, PI-1 transistor turns on. This causes Q9 to turn off which allows Q1 and Q5 to turn on causing motor current to flow. The motor rotates in the direction to cause the arm position to relocate the shutter to block the light.

4.11. Transformer for Motor Drive

Transformer T2 (Figure 11.3.) provides power to drive the reel motors at the proper speed. The transformer also isolates the amplifiers and motors from the 115V AC line.

4.12. Rewind Control

The tape is rewound when the Control commands the tape reader to drive the tape backwards from right to left. The reeler, being bidirectional, follows the reader and automatically takes up tape on the left and supplies tape from the right reel. The reader may rewind at a speed of either 150 CPS or 250 CPS. The speed of rewind is determined by the drive circuits for the sprocket drive motor. The particular speed of rewind used in a Control depends on the particular options chosen.

4.13. Broken Tape Interlock

Two Broken Tape switches (3SW and 4SW, Figure 11.3.) are provided, one for each tape loop arm. Each arm actuates its switch about 1/8" before the stop when it is pulled toward the center by its return spring. Each switch is a single-pole double-throw switch. Referring to Figure 11.3., when either switch is actuated separately, a contact closure is made between pins D and E of TB3 which outputs a broken tape condition to the Control. If both switches are actuated or neither is actuated, then no contact closure is made between pins D and E of TB3 and a broken tape condition is not outputted to the Control.

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The two reel motors, the tension arms and feedback assemblies plus the control circuit associated with each motor, comprise two separate closed-loop servo systems. The motors are DC operated with permanent magnet fields.

Motor rotation is initiated by an armature current extracted from the 115 VAC primary source. Each motor armature is driven from the AC line through a transformer, rectifier and two transistors for each motor. The transformer sets the amplitude of the voltage applied to the motors to determine their speed, and the transistors determine the polarity of the DC voltage. The polarity of the resultant armature voltage determines the direction of motor rotation, and the amplitude determines the speed. The detailed means by which armature current is applied to control motor operation is discussed in the paragraphs which follow. Since the two servo systems are identical, only the left-hand system will be described.

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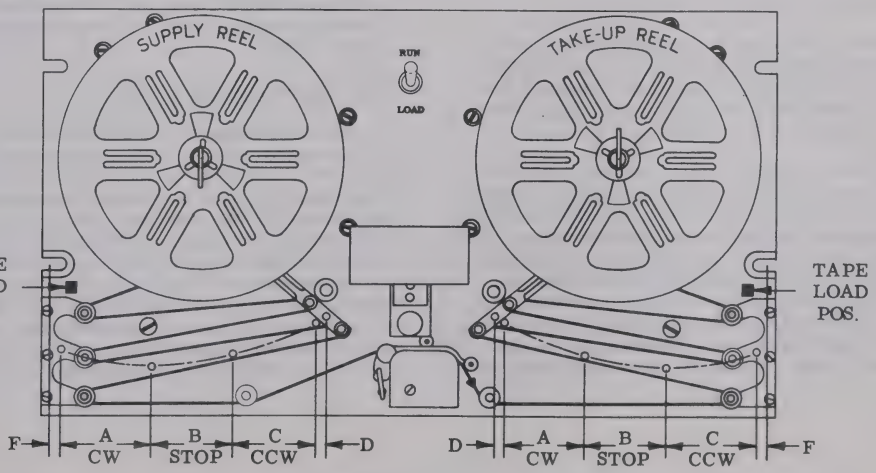

Figure 4.1.
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A fourth zone, D, is provided when the arm gets close to the Broken Tape switch and mechanical stop. When the tape breaks, the arms, because of the springs attached to them, move toward the mechanical stops located near the center of the panel. Each arm actuates a Broken Tape switch just before it hits the stop. Actuation of either Broken Tape switch provides an output to the Control that the tape has broken. When either arm is resting on the stop, the corresponding reeler motor is disabled.

A fifth zone, F, is provided to disable the corresponding reeler motor when the tension arm is in the clip which holds the tension arm during tape loading. The tension arms must be released from the clip after tape loading for normal running operation.

When loading tape, the Run/Load switch should be in the LOAD position which disables the reelers. The tension arms are moved to the extreme outward position and are held by arm load clips. With the arms in this position, the reelers are additionally disabled such that if the Run/Load switch is put in the RUN position, uncontrolled unwinding of tape off the reels is prevented.

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Transformer T2 (Figure 11.3.) provides power to drive the reel motors at the proper speed. The transformer also isolates the amplifiers and motors from the 115V AC line.

4.12. Rewind Control

The tape is rewound when the Control commands the tape reader to drive the tape backwards from right to left. The reeler, being bidirectional, follows the reader and automatically takes up tape on the left and supplies tape from the right reel. The reader may rewind at a speed of either 150 CPS or 250 CPS. The speed of rewind is determined by the drive circuits for the sprocket drive motor. The particular speed of rewind used in a Control depends on the particular options chosen.

4.13. Broken Tape Interlock

Two Broken Tape switches (3SW and 4SW, Figure 11.3.) are provided, one for each tape loop arm. Each arm actuates its switch about 1/8" before the stop when it is pulled toward the center by its return spring. Each switch is a single-pole double-throw switch. Referring to Figure 11.3., when either switch is actuated separately, a contact closure is made between pins D and E of TB3 which outputs a broken tape condition to the Control. If both switches are actuated or neither is actuated, then no contact closure is made between pins D and E of TB3 and a broken tape condition is not outputted to the Control.

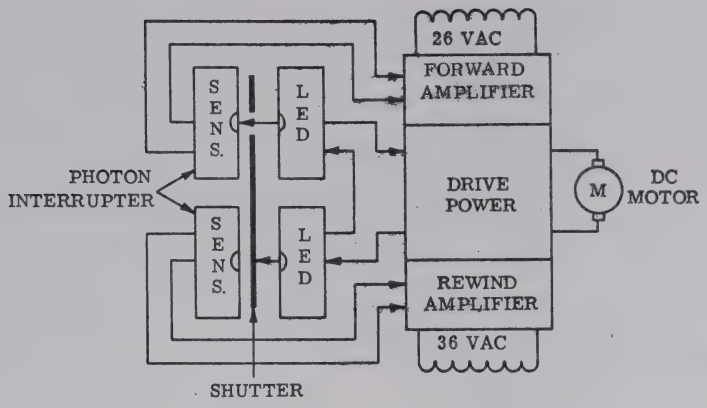

Figure 4.2.
SIMPLIFIED BLOCK DIAGRAM OF THE REEL MOTOR DRIVE

4.14. Run Load Switch and Interlock

The Run-Load switch (1SW, Figure 11.3.) is provided on the front panel. In the RUN position, one pole of the switch applies power to the reel servo photon interupters permitting the reel servos to run. The second pole on the switch is used to indicate to the Control that the switch is in the RUN position. The Control will then start and stop the reader when the operator actuates devices on the control panel for the system.

When the switch is in the LOAD position, power is prevented from reaching the reel servo photon interupters stopping the reel servos from running. Also, an output is provided to the Control indicating the tape reader is in load.

CAUTION

When the Run/Load switch is in the LOAD position, rewind is not inhibited. Therefore, do not cause rewind to be activated when the switch is in the LOAD position because of the possibility of damaging the tape.

4.15. Reels - Loop Operation

In the reader/reeler, operation in the Loop mode requires that both tension arms be in the same relative position: both arms resting on the rubber bumpers or both retained in the arm loading clips. This prevents an output from the Reader/Reeler indicating a broken tape condition which would cause the Control to stop operation.

SECTION 5
OPERATION

READER

5.1. OPERATOR'S DEVICES

The only Operator's device on the tape reader is the upper tape guide. Its use by the operator when he loads tape is explained below.

5.2. OPERATING PROCEDURES

With the tape properly loaded and power applied to the unit, operation is automatic and responsive to externally generated Control signals sent to the stepping motor. Procedures for loading and threading tape are covered in the paragraphs which follow.

5.3. TAPE LOADING - LOOPS AND STRIPS (See Figure 5.1.)

The procedure for loading tape is as follows:

1. Lift the upper tape guide (part 1, Figure 5.1.).

2. Place the tape into the lower guide, making sure that the sprocket holes in the tape are properly engaged with the teeth of the sprocket drive wheel. The sprocket channel should be the fourth hole position from the reader front panel.

3. Lower the upper tape guide. The reader is now ready for operation.

4. If it is desired to have a particular character loaded in the READ position, load the tape with power on. If the character is loaded with power off, applying power can cause the character to be stepped off position. Also, if power is turned off and then on again, the character can also be stepped off position.

5.4. LENGTH OF TAPE

The unit is capable of operating with tape loops or strips of minimum 4 foot (running) length. Strips should have a minimum of 10 inches of leader preceding and following the data.

READER/REELER

5.5. OPERATOR'S DEVICES

The four Operator's devices on the Reader/Reeler are shown in Figure 5.2. and are listed below.

1. Upper tape guide - Permits loading the tape in the reading head.

2. Run/Load Switch - Turns off power to the reeler motors and signals the Control to stop the step motor from stepping to permit the operator to load the tape.

3. Reel Retainer Latch - Locks reels in place on the reeler motor shaft.

4. Arm Load Clips - Holds tension arms in place when loading and unloading tape.

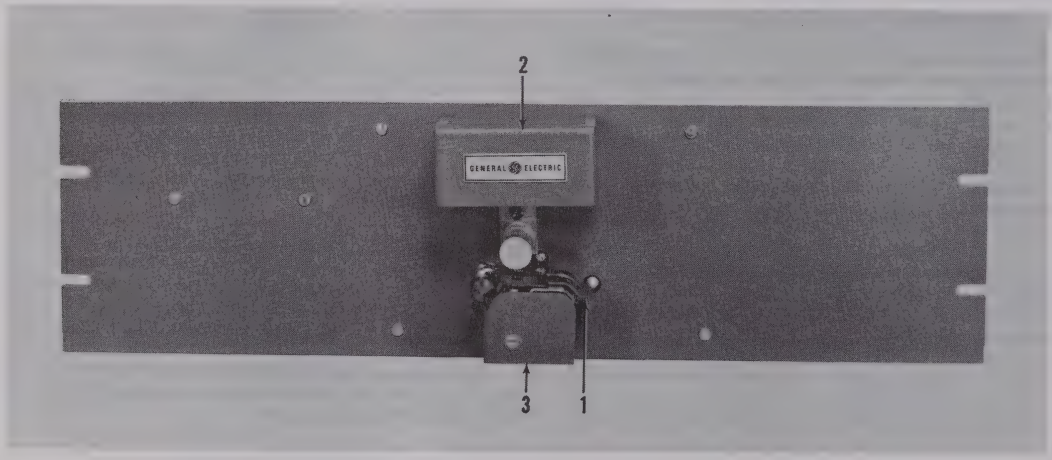

Figure 5.1.
OPERATOR'S DEVICES FOR THE READER

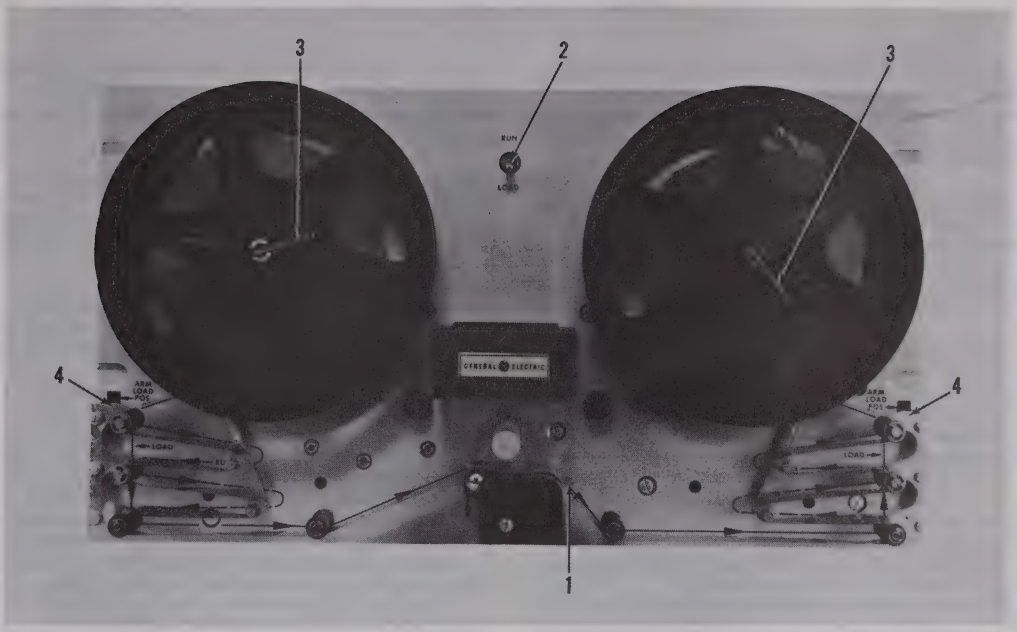

Figure 5.2.
OPERATOR'S DEVICES FOR THE READER/REELER

5.6. OPERATING PROCEDURES

With the tape properly loaded and power applied to the unit, operation is automatic and responsive to externally generated control signals sent to the stepping motor. Procedures for loading and threading tape are covered in the paragraphs which follow.

5.7. TAPE LOADING

LOOPS AND STRIPS

The procedure for loading tape is as follows:

1. Put the Run/Load switch in the LOAD position and both arms either resting against the rubber bumper stops or both arms retained in the load clips (to avoid a broken tape input to the Control when the reader is running).

2. Lift the upper tape guide (part 1, Figure 5.2.).

3. Place the tape into the lower guide, making sure that the sprocket holes in the tape are properly engaged with the teeth of the sprocket drive wheel. The sprocket channel should be the fourth hole position from the reader front panel. The tape should be on top of the two fixed guide rollers on either side of the read head.

4. Lower the upper tape guide and put the Run/Load switch in the RUN position. The reader is now ready for loop or strip operation.

REELS

The procedure for loading tape is as follows:

1. With power on, put the Run/Load switch (part 2, Figure 5.2.) in the LOAD position. Put the tension arms in the arm load clips (part 4, Figure 5.2.).

2. Lift the upper tape guide (part 1, Figure 5.2.).

3. Place an empty reel on the right-hand reel hub, and close the latch (part 3, Figure 5.2.).

4. Place the program reel of tape on the left-hand reel hub, taking care that the reel is positioned so that the sprocket track is nearest the front panel and the tape is feeding off the reel in the manner indicated by the marking on the panel. Close the latch.

5. The tape leader should be approximately five feet in length for easy loading. Take enough leader to attach to the empty right reel and manually rotate the right reel, clockwise, through four or five complete wraps.

CAUTION

Do not place any adhesive (scotch or masking tape in particular) on the tape to hold it to the reel during loading. This causes a problem when unreeling the tape off the right reel since the end of the tape will not release from the reel properly. This causes it to wind up the wrong way on the right reel, resulting in a tug-of-war between the right reeler and the step motor, with possible tape damage resulting.

6. Rotate the left reel to form a large downward loop of tape sufficient to thread between the three fixed rollers and the two tension arm rollers on each side of the front panel and to leave some slack for threading through the readhead and under the rollers on each side of the readhead. The threading pattern outlined on the front panel is a proper guide for loading the tape.

7. Place the tape into the lower guide in the readhead, making sure the sprocket holes in the tape are properly engaged with the teeth of the sprocket drive wheel. The sprocket channel must be the fourth hole position from the front panel.

8. Lower the upper tape guide to hold the tape in position in the readhead.

9. If it is desired to have a particular character loaded in the READ position, load the tape with power on. If the character is loaded with power off, applying power can cause the character to be stepped off position. Also, if power is turned off and then on again, the character can also be stepped off position.

10. Carefully release the tension arms from the arm clips and allow the arms to take up the remaining slack in the tape, checking that the tape is properly centered in each of the rollers.

11. Should there be excessive slack, the tension arms will reach the CENTER STOP and LIMIT position. In this case, rotate the reels so that the tension arms are pulled near the center of their travel to the RUN position outlined on the front panel.

12. Put the Run/Load switch in the RUN position. If the tape tension arms are not in the center stop zone, the corresponding motor may turn on to supply or take up tape to move the arm into the stop zone.

NOTE

When the tape tension arms move as described above, they should not move to their inner stops. If either tension arm contacts the stop, it activates the broken tape interlock which interrupts power to that reeler and outputs a broken tape condition to the Control. If this occurs, set the Run/Load switch to the LOAD position, and rotate the reels until the tension arms move to a point approximately below the center of the reel. Then set the Run/Load switch to the RUN position. The motors will automatically commence to take up slack and cause the tension arms to seek their normal operating position. Reset the Control to clear the broken tape indication.

5.8. LENGTH OF TAPE

Loops and Strips: The unit is capable of operating with tape loops or strips of a minimum of 4 feet (running) length. Strips should have a minimum of 10 inches of leader preceding and following the data.

Reels Tapes: There should be 5 feet of leader at both ends of a tape which is used on a reader with reels so that there will be sufficient leader to (a) thread the reader and reels and (b) to coast past the Rewind Stop character when the tape is rewound.

On tapes which have more than one program on a reel, there should be a minimum of 2 inches of tape between the two programs. This will allow the tape to stop after rewinding before reaching the end of the previous program.

SECTION 6
CHECKS AND ADJUSTMENTS

6.0. GENERAL

This section presents the adjustment and alignment procedures required to obtain optimum performance from the equipment. All tapes must be punched within the tolerances of EIA* standard RS-227A.

WARNING

Dangerous voltages exist in this equipment. Exercise caution when performing any of the following checks or adjustments.

6.1. GENERAL READ HEAD ALIGNMENT

A visual observation of the read head alignment when it has a tape installed for production operation for either a reader or reader with reels should appear as follows at stand still. The light line as viewed on the surface of the tape should be bright and have a constant width across the tape slightly less than the sprocket hole diameter. The light line should also be reasonably centered on the sprocket and data holes.

Lamp voltage can be checked per paragraph 6.3. and light line width adjustment can be checked per paragraph 6.4. A tape track off-center condition can be caused by:

A. Worn tape with sprocket hole elongation does not allow the sprocket wheel to pull the tape to the light line. Replace the tape.

B. Lamp bulb replacement causes a shift in the light line position. Check that the light line is centered in the aperatures of the solar cell. If it is not centered, readjust the light line per paragraph 6.4., step 2.

C. Lens out of position causes a shift in the light line position. Check that the light line is centered in the apertures of the solar cell. If it is not centered, readjust the light line per paragraph 6.4., step 2.

D. Sprocket wheel mis-alignment. Adjust the sprocket wheel per paragraph 6.6.

The solar cell output can be checked per paragraph 6.5., solar cell skew can be checked per paragraph 6.7. and finally the complete alignment of the read-head is contained in paragraph 9.11.

6.2. READ HEAD MECHANICAL ALIGNMENT CHECK

Improper read head alignments can result in reduced tape life. The following checks should be made to assure proper alignment to minimize tape life degradation.

1. With power off, check the height of the sprocket wheel. When in proper adjustment, only the teeth of the sprocket wheel should be seen above the surface of the lower tape guide (including the curved portion). The solid part of the sprocket wheel should be flush with the lower tape guide surface. If the adjustment is not proper, loosen the screws holding the step motor or the step motor heat sink to the front panel. Slide the motor assembly until the sprocket wheel is in proper adjustment. Tighten the screws. This adjustment will probably require readjusting the tape under the light line described in paragraph 6.6.1 or 6.6.2.

2. Spin the step motor to see that it spins freely and that the sprocket wheel spins true. If the motor appears to bind, replace the step motor per paragraph 9.10. If the sprocket wheel wobbles badly, the step motor shaft may be bent. Replace the step motor per paragraph 9.10.

3. Check that the upper tape guide in its DOWN position sets properly on the 2 buttons on the top surface of the lower tape guide. Also check for a clearance of .012 inches minimum between the upper and lower tape guides including the curved portion. Then check that the upper tape guide has at least .01 inches of clearance between the fixed bullet nose tape guide and that portion of the upper tape guide that protrudes out over the fixed guide. Also check that the upper tape guide is parallel with the lower tape guide (upper tape guide not bent away from the front panel). Adjust the upper tape guide by carefully bending it (without scratching its surfaces) so that it is in proper alignment. If necessary, replace the upper tape guide per paragraph 9.6.

4. Place a tape in the read head and check that it lies flat on the lower tape guide. If it does not, the sprocket wheel may not be the proper distance from the front panel. First check that the step motor is installed in its heatsink properly per paragraph 6.6.2. step 6. If it is, then adjust the sprocket wheel so that the tape lies flat on the lower tape guide. Tighten the sprocket set screws and recheck with the tape.

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6.3. LAMP VOLTAGE CHECK

1. Apply power to the unit and check to see that voltage between TB2-B and TB2-C is 12V ±2%.

2. To read the voltage at the lamp, connect a DC voltmeter between the lamp socket base and the lamp end of R1.

3. The voltage should be 9.2V ±.4V. The exact voltage is determined by the resistance in the wires between the power supply and the Reader. There is no lamp voltage adjustment in the Reader or in the Control. (On earlier units with the lens in the gray casting, the voltage should be 10.0 ±.4 VDC.)

6.4. LIGHT LINE ADJUSTMENT

1. Insert a loop of tape with only sprocket holes punched in the unit. Check that the light line is nearly the width of the sprocket hole (approximately 0.04 inches). Adjust for this focus by first slightly loosening the 2 lens mounting screws. Then adjust the lens up or down to focus the narrowest possible light line on the tape surface. Then lower the lens until the light line is slightly less than the width of the sprocket hole. Note that this adjustment is to be made on the surface of the tape, not at the photocell glass or at the cell mask apertures.

2. Remove the loop of tape and carefully move the lens sideways to center the light line in the apertures of the cell mask. Then using the procedure for measuring sprocket cell output described in paragraph 6.5., move the lens sideways for maximum sprocket cell output. Tighten the lens mounting screws and clean the lens with a soft cloth.

3. Insert a fully punched tape (all holes punched) and check that the proper focus has been maintained.

4. Check that the light line is centered in the character punched holes. If not, adjust the step motor to correctly position the tape per paragraph 6.6.1. step 9, or 6.6.2. step 7. Also check that the light line is not skewed (light line not perpendicular to the front panel such that the light line is centered in track 1 but not in track 8). If it is skewed, check for a faulty lamp, lens, or tape.

6.5. SOLAR CELL OUTPUT

The following check verifies that the output of the solar cells is within its tolerance level.

1. Disconnect the wires going to the solar cell amplifier. Cell output measurements are to be made between the specific channel output to be measured and cell common. (See Figure 11.1. or 11.2.)

2. Connect a 0-1 milliammeter with 100 ohms or less internal resistance across the cell, or connect a 100 ohm resistor across the cell and connect an oscilloscope with 10 millivolts per cm. deflection across the resistor.

Prior to making cell output measurements, perform the checks of paragraphs 6.3. and 6.4.

3. Insert a fully punched tape and check the solar cell outputs. The measurements should be within the following limits.

A. Data tracks (.072 in. hole)

minimum output = 0.375 ma or 37.5 mv

maximum output = 1.200 ma or 120 mv

B. Sprocket (.046 in. hole)

minimum output = .300 ma or 30 mv

maximum output = .900 ma or 90 mv

4. If these outputs are not obtained on all tracks, inspect the lamp and clean it if it is dirty or replace it if it is discolored (blackened). Recheck per paragraphs 6.3. and 6.4. and measure again. If the outputs are still not obtained, check for peak sprocket output by rotating the sprocket wheel slightly by finger to see if the tape is positioned properly over the cell apertures. Reposition the tape by adjusting the sprocket wheel per paragraph 6.6.1. step 7 or 6.6.2. step 6. If the proper cell outputs are still not obtained, replace the solar cell assembly per paragraph 9.11.

6.6. SPROCKET WHEEL ADJUSTMENT

WARNING

If the motor has been operated just prior to the time you make the adjustment, take care in handling the motor body as it gets very hot. Gloves may be required.

6.6.1. READER

1. Remove the lower head cover, and with the power off, turn the sprocket wheel until one of the set screws

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points downward. Loosen it. Then turn the wheel so that the remaining set screw is pointing downward. Make a pencil mark on the outside face of the wheel opposite the set screw.

2. Hold the wheel with the set screw pointing down, and turn the power to the motor on. The motor should lock into position so that the set screw can still be reached easily.

3. Connect a 100-ohm resistor and an oscilloscope to the sprocket track output per paragraph 6.5. (A 0-1 milliampere meter with a 100-ohm resistance or less may be used in place of the 100-ohm resistor and oscilloscope.)

4. Check to see that the light line adjustment agrees with that specified in paragraph 6.4.

5. Loosen the two screws holding the lens, and with no tape in the reader, peak the sprocket cell current by moving the lens assembly from side to side and tighten the lens at the peak output.

6. Install a fully punched loop of tape in the Reader. The tape must be punched within the tolerances of EIA* Standard RS-227, particularly with regard to feedhole spacing.

7. Rotate the sprocket wheel until the sprocket cell current is at a maximum. Then tighten the set screw. While making this adjustment, position the sprocket wheel axially so that the tape lies flat on the lower tape guide.

8. Turn off Control power in order to turn the sprocket wheel. Tighten the second set screw, and then turn Control power on again.

9. Check to see that the adjustment is correct by moving the sprocket wheel slightly by finger off the DETENT position on either side. The maximum current from the sprocket cell should be at the DETENT position and not on one side or the other. Repeat step 7 until this requirement is met.

10. Replace the lower head cover.

6.6.2. READER/REELER

1. With power on and a tape installed in the readhead, check that the tape lies flat on the lower tape guide. If not, adjust the sprocket wheel as follows. Remove power from the Control. Then remove the lower head cover and loosen both sprocket wheel set screws. Position the sprocket wheel so that the tape lies flat on the lower tape guide and tighten both set screws. Replace the lower head cover and apply power.

2. Connect a 100-ohm resistor and an oscilloscope to the sprocket track output per paragraph 6.5. (A 0-1 milliampere meter with a 100-ohm resistance or less may be used in place of the 100-ohm resistor and oscilloscope.)

3. Check to see that the light line adjustment agrees with that specified in paragraph 6.4.

4. Loosen the two screws holding the lens, and with no tape in the reader, peak the sprocket cell current by moving the lens assembly from side to side and tighten the lens at the peak output.

5. Install a fully punched loop of tape in the Reader. The tape must be punched within the tolerances of EIA* Standard RS-227, particularly with regard to feedhole spacing.

6. Loosen the clamp screw which holds the step motor in its heat sink, and rotate the step motor until the sprocket cell current is at a maximum. Then tighten the heat sink clamp screw. With power off, check that the step motor is free to rotate without binding. If binding occurs, replace the step motor per paragraph 9-10.2. During this adjustment, make sure the step motor is bottomed out in the heat sink.

7. With power on, check to see that the adjustment is correct by moving the sprocket wheel slightly by finger off the DETENT position on either side. The maximum current from the sprocket cell should be at the DETENT position and not on one side or the other. Repeat step 6 until this requirement is met.

8. Replace the lower head cover.

6.7. READ HEAD SKEW CHECK

If tape reading errors cause the Control error sensing circuits to be activated, check the following items.

1. The tape is in good condition.

2. The readhead is clean and in proper adjustment per paragraph 6.2.

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3. The light line adjustment is per paragraph 6.4.

4. The solar cell output is per paragraph 6.5.

If all of the above checks are good, proceed as follows. A properly adjusted read head meets the following conditions.

1. When coming into a character position, the sprocket channel is the last channel to change state.

2. When leaving a character position, the sprocket channel is the first channel to change state.

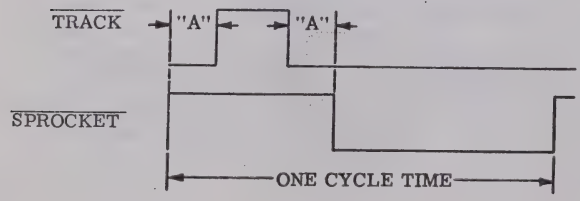
If these conditions are not met, then excessive read head skew is present and parity errors will result. The skew check can be made simply by looking at the outputs of the track amplifier printed-circuit board (DA-91, TRAD1, TRAD2) located in the Control. A dual trace scope is required. The outputs of the amplifiers are in the low state when reading a tape hole (light shining on the solar cell). Otherwise, the outputs are in the high state. The skew check procedure is as follows.

1. Install a loop of tape in the reader with 8 holes punched in each character position. For reelers, have both tension arms resting on the rubber bumper stops or both retained in the loading clips. Put the Run/Load switch in the RUN position.

2. Put the Control in the Auto or Single Mode and initiate cycle start. This causes the tape reader to run forward continuously and the track amplifier outputs will be available for measurement.

3. Connect the scope so that the first trace is on the sprocket output from the track amplifier board. External trigger the scope on the rising edge of the sprocket signal and adjust the sweep for one cycle.

4. Connect the scope so that the second trace is on a track output from the track amplifier board. The pattern displayed should look approximately as follows:



5. Check each track versus the sprocket. The read head skew is acceptable when both values of "A" shown in the sketch are greater than 5% of the one-cycle time for all tracks. Skew will usually be most noticeable between tracks 1 and 8.

6. If the reader fails the skew test, the tape may be at fault. Remove the tape, turn it inside out, and reload it in the normal manner (sprocket hole fourth from the front panel). Rerun the test. If the skew reverses, check the tape. If the skew remains essentially the same, then adjust the solar cell assembly per paragraph 9.11., steps 21 and 22 and repeat the skew test.

6.8. STEP MOTOR RATES

The stepping rate of the step motor is controlled by the motor drive board (TRD2, TRAD1, TRAD2) located in the control. The nominal stepping rate is 150-CPS forward and 250-CPS rewind. There is no adjustment provided for these rates.

6.9. REEL BRAKE TORQUE AND WEAR CHECK

1. To check the reel motor brake torque, proceed as follows. Check each reel motor brake.

A. With power off and reels removed, connect a 0-1 amp ammeter in series with the reel motor. Place the Run/Load switch in the RUN position.

B. Turn power on and move the appropriate tension arm to the position that causes the particular reel motor to rotate counterclockwise (rewind direction). Allow the motor to run for 2 minutes.

C. Measure the motor current. For a properly adjusted brake, the current should be between 0.62 and 0.68 amp.

2. To adjust the reel motor brake torque, turn the power off. Loosen the 2 set screws that hold the brake hub on the reel hub. For greater current, push the brake hub in; for less current, let it out. Retighten the set screws and check the new adjustment per step 1, B and C.

3. If the proper adjustment cannot be achieved, the brake lining may be worn through. Replace the linings per paragraph 9.17.

6.10. REEL MOTOR OPERATION CHECK AND SHUTTER ADJUSTMENT

This check is made to see if the reel motors switch on and off at the proper locations in the travel of the tape tension arms.

1. With the reels removed, the arms retained in the arm load clips, and the Run/Load switch in the RUN position, turn power on. Check that both reel motors are off.

2. Move the right arm out of its clip and check that the right reel motor starts to rotate counterclockwise just as the arm leaves the clip or up to 1/8 inch away from the clip. While moving the arm towards the center, check that the motor stops in the vicinity of the outer dot on the front panel. Continue to move the arm toward the center and check that the motor starts to rotate clockwise in the vicinity of the inner dot on the front panel. Continue to move the arm towards the center and check that the motor stops prior to actuating the Tape Break switch. Let the arm rest on the rubber bumper stop and check that the motor remains stopped.

3. Repeat step 2 for the left arm and left reel motor except interchange the counterclockwise and clockwise motor directions.

The only adjustment in the reel servo to correct for misalignment is the adjustment of the shutter support block in the feedback assembly for positioning the shutter.

CAUTION

Always turn power off before removing the feedback assembly covers. Do not turn power back on again until the covers are in place. The photon-interrupters on the RSF1 board in the feedback assembly are very sensitive to stray ambient light. Power on with the covers removed could cause catastrophic damage to power transistors on the RSD3 printed-circuit board.

The proper position of the shutter is governed by the reel motor turn-on as the tension arm leaves the arm load clip. The procedure for this adjustment is as follows.

4. If the shutter is out of adjustment, note the arm position at which the reel motor starts to turn.

5. Turn off power and remove the cover of the feedback assembly. Loosen the set screw that holds the shutter support block to the shaft and rotate the shutter support block carefully in the direction that the arm is off. Note that a small rotation of the block results in a multiplier of 10 in the final arm position. Tighten the block set screw. Check that when the arm is moved through its entire travel, the shutter does not rub on the photon-interrupter surfaces.

6. Replace the feedback assembly cover and turn on power. Check that with the tension arm retained in the clip that the reel motor is off, and as the arm leaves the clip, that the motor turns on within 1/8 inch from where the arm last touches the clip ends. If the adjustment is still off, repeat steps 5 and 6.

6.11. BROKEN TAPE LEVER SWITCH ACTUATION POINTS

This adjustment is made so that when the tape tension arms are allowed to go to their rest positions (on the bumpers), the limit switches are actuated prior to the arms hitting the rubber bumper.

1. Loosen the mounting screws for the limit switch bracket to be adjusted.

2. Adjust the bracket so that the switch is actuated when the switch lever is in the center of the lever hole in the front panel.

3. Tighten the bracket mounting screws.

SECTION 7
PREVENTIVE MAINTENANCE

7.1. MAINTENANCE SCHEDULE

The following table has been prepared to give guidance to our customers and to assist them in obtaining optimum performance from their equipment.

TABLE 7.1.
MAINTENANCE SCHEDULE

ITEM	ACTION	TIME INTERVAL
Lamp/Lens	Dust, using a soft cloth, cotton swab, or brush from the maintenance kit.	As required or weekly
	Clean using sparing amounts of pure isopropyl alcohol (minimum 90%).	500 hours
Tape Guides, Reader Photocell Assembly and Rollers	Dust, using a soft cloth, cotton swab, or brush from the maintenance kit.	As required or weekly
	Clean, using sparing amounts of pure isopropyl alcohol. Remove the plastic rollers and clean the spindles and rollers.	500 Hours
Photon-Interrupters in Reel Feedback Assemblies	Remove the cover of the feedback assembly. Loosen the set screw holding the shutter support in the feedback assembly and rotate the shutter out of the way. Clean the faces of the photon-interrupters with a cotton swab dipped in pure isopropyl alcohol. Reset the shutter support block per paragraph 6.10.	2000 Hours or as required.
Step motor and Reel Motors	NO LUBRICATION is required for the life of the components.	
Reel Motor Brushes	Check the length of the brushes and replace them when their length is 5/16" or less. When the brushes are removed for checking, each brush must be replaced in the same holder from which it was removed.	Check the brush length every 2000 hours and replace it as necessary.
Reel Shaft Assembly "O" Ring	Check for excessive wear causing the reel to be loose on the shaft or having a short reel life.	1000 Hours or as required.

7.2. TOOLS AND TEST EQUIPMENT

The outline below lists tools and test equipment required to perform routine maintenance and adjustment.

TABLE 7.2.
TOOL AND TEST EQUIPMENT REQUIRED

ITEM	USE	MODEL OR TYPE	QTY.
Wrenches (Allen)	General	Standard	1 Set
Wrenches (Open Face)	General	Standard	1 Set
Wrenches (Socket)	General	Standard	1 Set
Screwdrivers	General	6" - Electrical 12" - Electrical	1 1
Pliers, Long-Nosed	General	Standard	1 Pair
Oscilloscope	Solar Cell	Tektronic Type 561A with a 3A1, 3A6, or 3A72 preamplifier	1
Meter, Volt-Ohm-meter	General Test	Simpson 260 or equivalent	1
Meter, Microammeter	Photocell Output Paragraph 9.11. step 21.	0 - 50 microamp	1
Meter, Milliammeter	Photocell Output. Paragraph 6.5.	0-1 ma	1
Meter, Ammeter	Brake Torque Adjust Paragraph 6.9.	0 - 1 amp	1
Maintenance Kit:		Reference Drawing 44A395910-001	
Brush Shim 0.002" (red) Shim 0.003" (green) Shim 0.005" (blue) Shim 0.010" (brown) Shim 0.015" (pink) Shim 0.030" (coral) Reel Shaft "O" Rings			4

SECTION 8
TROUBLESHOOTING

8.0. TROUBLESHOOTING GUIDES

WARNING

Dangerous voltages exist in this equipment. Exercise caution when troubleshooting this equipment.

Table 8.1. contains troubleshooting information for use by maintenance personnel as an aid in the maintenance of the Reader.

Table 8.2. contains additional troubleshooting information pertaining to the Reeler portion of a Reader/Reeler.

Before you start troubleshooting, be sure that the tape is clean and of good quality. Also, the tape perforations must not be skewed or frayed and the punched holes must be within the tolerance limit.

NOTE: Always be sure the lamp, lens and reading head are properly cleaned and in proper adjustment before and after troubleshooting.

TABLE 8.1.
TROUBLESHOOTING GUIDE, READER

SYMPTOM	PROBABLE CAUSE	CORRECTIVE ACTION
There is no photosensor output; the stepmotor shaft is not rotating.	The lamp has burned out or blackened.	Replace the lamp and check the light line alignment per paragraph 6.4.
	Lamp operating voltage is off or incorrect.	Check for lamp voltage per paragraph 6.3.
There is no photosensor output; the lamp is on.	The photosensor unit is dirty.	Clean the photosensor unit, lens and lamp.
	There is a broken lead on a photocell or photocell is bad.	Resolder the lead or replace the solar cell assembly.
There is an occasional sensor dropout or spurious outputs.	The read area is dirty.	Clean the photosensor unit, lens and lamp.
	The lamp is weak.	Check the lamp voltage per paragraph 6.3. Replace the lamp and check the light line alignment per paragraph 6.4.
	The lamp is installed in the socket upside down.	Remove the lamp and reinstall it right side up. See Figure 9.1. for clarification. Clean the lamp with a soft cloth. Check the light line alignment per paragraph 6.4.
	The sprocket wheel is out of adjustment.	Adjust the sprocket wheel per 9.11., step 15 and then paragraph 6.6.
There are excessive errors.	Dirt may be on the lamp, lens or on the solar cell assembly.	Clean the photosensor unit, lens and lamp.
	The tape is bad.	Replace the tape.
	The sprocket wheel is out of adjustment.	Adjust the sprocket wheel per paragraph 6.6. and/or paragraph 9.11.
	The lens is out of adjustment.	Adjust the lens assembly per paragraph 6.4.
	There is excessive Reading head skew.	Check and adjust per paragraph 6.7.

(Continued)

SYMPTOM	PROBABLE CAUSE	CORRECTIVE ACTION
The tape is not moving.	The tape is not properly engaged with the sprocket wheel.	Reload the tape properly, engaging the sprocket wheel teeth in the sprocket holes in the tape.
	The sprocket wheel is loose on the motor shaft.	Adjust and tighten the set screw on the sprocket wheel hub, per paragraph 6.6.
	The drive pulses to the motor are not of sufficient amplitude and duration, or one phase does not turn off.	Replace the drive board (located in the Control).
	There may be loose electrical connections on TB1 or TB2.	Check all connections for tightness.
	One motor winding is shorted to the case.	Check resistance to the case (which is grounded) and replace the motor if it is shorted.
The tape does not stop on character.	One winding of the motor does not remain energized when the tape is supposed to stop.	Replace the drive board (located in the Control).
	One winding of the motor is burned out or shorted.	Replace the motor.

TABLE 8.2.
TROUBLESHOOTING GUIDE, REELER

SYMPTOM	PROBABLE CAUSE	CORRECTIVE ACTION
One or both reel motors run and spill tape when power is applied.	The tape is improperly threaded.	Rethread the tape properly per 5.3. or 5.7.
	There is a shorted photon interrupter.	Replace the RSF1 printed-circuit board.
	There is a faulty component on the RSD3 printed-circuit board.	Replace the board.
	The shutter in the feedback assembly is out of adjustment.	Adjust the shutter per paragraph 6.10.
One reel motor will not run in both directions of rotation.	There is an open photon-interrupter.	Replace the RSF1 printed-circuit board.
	Not enough light is reaching the photon interrupter.	Clean the photon interrupter per Table 7.1.
	The shutter in the optical feedback assembly is out of adjustment.	Adjust the shutter per paragraph 6.10.
	Brushes on the reel motor are worn.	Replace the brushes.
	There is a faulty component on the RSD3 printed-circuit board.	Replace the board.
Reel Motor will not run.	One or both arms are on the Broken Tape switch.	Take up the slack in the tape.
	The Run/Load switch is in the LOAD position.	Put the Run/Load switch in the RUN position.
	The RSD3 printed-circuit board has failed.	Replace the board.
	The Run/Load switch is faulty.	Replace the switch.
	There is an open winding on the input transformer.	Replace the transformer.
	The reel motor has failed.	Replace the motor.
The tension arms hit the stop and the reel motor continues to run.	The motor switching points are out of adjustment.	Check the switching points and adjust them per paragraph 6.10.
	The RSD3 printed-circuit board has failed.	Replace the board.

(Continued)

SYMPTOMS	PROBABLE CAUSE	CORRECTIVE ACTION
The reels do not take up or give out tape fast enough.	The brake is set too high.	Adjust the brake per paragraph 6.9.
	The input voltage is low.	Check the line input voltage.
	The RSD3 printed-circuit board is faulty.	Replace the board.
The tape tension arm has excessive oscillation.	The brake is set too low.	Adjust the brake per paragraph 6.9.
Reel is loose on shaft.	Worn "O" Ring.	Replace the "O" Ring.

SECTION 9
PARTS REMOVAL AND REPLACEMENT

9.1. PARTS REPLACEMENT SCHEDULE

Table 9.1. contains a recommended schedule for replacement of parts in the Reader and Reeler. The table lists suggested spare parts stock, based upon the number of units in use. All parts are kept in stock and can be shipped within 24 hours from receipt of order. When the application is critical or where downtime is a serious factor, use of a spare Reader or Reader/Reeler should be considered.

TABLE 9.1.
PARTS REPLACEMENT SCHEDULE

PARAGRAPH REFERENCE	ITEM	REPLACEMENT INTERVAL	SUGGESTED STOCK QUANTITY PER NUMBER OF UNITS
9-3	Lamp	2000 hours	2 Each
9-24	Reel Motor Brushes	8000 hours	2 sets 1-20
9-23	Reel Shaft "O" Rings	1000 hours	20 1-5

9.2. LENS ASSEMBLY REPLACEMENT (8, Figure 10.1.; 4, Figure 10.4.)

1. Loosen the two mounting screws that secure the lens assembly to the panel face.
2. Remove the lens assembly.
3. Place the new lens assembly in position, and tighten the mounting screws.
4. Adjust the light line per paragraph 6.4.

9.3. LAMP REPLACEMENT (11, Figure 10.1.; 8, Figure 10.4.)

The lamp has a standard bayonet-type base. When installing a new lamp, make sure the long filament support inside the lamp is at the top. (See Figure 9.1.). After replacing a lamp, clean it with a soft cloth and make the following checks:

1. Lamp voltage per paragraph 6.3.
2. Light-line width and position per paragraph 6.4.

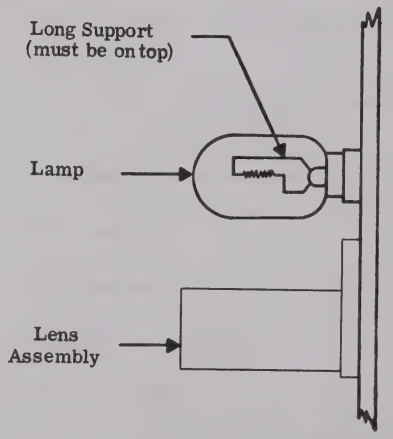


Figure 9.1.
PROPER INSTALLATION OF LAMP

9.4. SOLAR CELL ASSEMBLY REPLACEMENT (9, Figure 10.1.; 15, Figure 10.4.)

1. Disconnect power and remove the unit from the rack if necessary.

2. Remove the lens assembly per paragraph 9.2.

3. Remove the lower cover assembly (3, Figure 5.1.) by loosening the single mounting screw. Also remove the cell wire cover clip (13, Figure 10.1.; 14, Figure 10.4.) on the left side of the cell support.

4. Remove the upper tape guide tension spring (6, Figure 10.1; 17, Figure 10.4).

5. At the rear of the panel, remove the screw and washer that hold the flanged tape guide (12, Figure 10.1.; 16, Figure 10.4.) and the upper guide assembly (7, Figure 10.1.; 18, Figure 10.4.).

6. Remove the wires from TB1.

7. Remove the two screws that secure the solar-cell assembly (9, Figure 10.1.; 15, Figure 10.4.) to the cell support, and remove the cell assembly and the wire harness.

8. Place the new cell assembly in position, and replace, but do not tighten the cell-assembly mounting screws.

9. Connect the solar cell output wires to TB1 according to Table 3.2., and Figure 11.1. or 11.2.

10. Complete the assembly and adjustment of the read head per paragraph 9.11.

9.5. UPPER GUIDE TENSION SPRING REPLACEMENT (6, Figure 10.1.; 17, Figure 10.4.)

1. Grasp the end of the spring with long-nosed pliers, and disengage the spring from the hole in the front panel. Remove the other end of the spring from the hole in the upper guide assembly.

2. Hook the end of the new spring in the hole in the upper guide assembly. Grasp the other end of the spring with long-nosed pliers, and engage the spring in the hole in the front of the panel.

9.6. UPPER TAPE GUIDE AND FLANGED TAPE GUIDE REPLACEMENT (7, 12, Figure 10.1.; 16, 18, Figure 10.4.)

1. Disconnect power, and remove the unit from the rack if necessary.

2. Remove the lower cover assembly by loosening the single mounting screw.

3. Remove the upper guide tension spring (6, Figure 10.1.; 17, Figure 10.4.).

4. At the rear of the panel, remove the screw and washer that hold the flanged tape guide and the upper tape guide. Be sure to capture the upper guide tension spring as the upper guide is removed.

5. Install the new upper tape guide or flanged tape guide.

6. Check per paragraph 6.2., step 3.

9.7. LOWER GUIDE ASSEMBLY REPLACEMENT (2, Figure 10.1.; 11, Figure 10.4.)

1. Remove the lens assembly per paragraph 9.2.

2. Remove the upper tape guide and flanged tape guide per paragraph 9.6.

3. Loosen the two mounting screws which hold the lower guide in place. Remove the guide.

4. Mount the new guide in place; replace and snug tighten the guide assembly mounting screws.

5. Complete the assembly and adjustment of the head per paragraph 9.11., step 7 through 14.

6. Check the read head per paragraph 6.2., steps 1, 3, and 4.

9.8. DAMPER ASSEMBLY REPLACEMENT (3, Figure 10.2.; 12, Figure 10.6.)

1. Loosen the two set screws in the steel hub. Slide the steel hub, plastic disc, steel disc, plastic washer, plastic disc, steel washer, and spring off of the shaft.

2. Replace the worn or damaged parts, and reassemble the damper assembly on the shaft as shown in Figure 9.2.

3. With two 0.010" brown plastic shims (from the maintenance kit) in position as shown in Figure 9.2., load the flanged hub until the spring is compressed solid. Then tighten the set screws, and remove the shims.

9.9. SPROCKET WHEEL REPLACEMENT

9.9.1. READER (4, Figure 10.1.)

1. Disconnect power, and remove the unit from the rack if necessary.

2. Loosen the set screws in the hub of the sprocket wheel.

3. Remove the screws which hold the step motor to the front panel.

4. Move the step motor away from the panel with one hand. With your other hand, catch the sprocket wheel as it comes off the end of the motor shaft.

5. With a pencil, scribe lines on the outside surface of the new sprocket wheel to aid in later locating the set screws when tightening.

6. Install the step motor and temporarily tighten the mounting screws. Install the sprocket wheel loosely on the motor shaft as you install the motor on the panel.

7. Loosen the screws holding the motor to the baseplate. Slide the motor up or down until the tips of the sprocket teeth are 0.045" above the surface of the lower tape guide. This adjustment applies both to the horizontal top surface as well as the vertical surface on the right side. Tighten the mounting screws. Check the adjustment per paragraph 6.2., step 1.

8. Adjust the sprocket wheel as described in paragraph 6.6.1.

9.9.2. READER/REELER (12, Figure 10.4.)

1. Turn off power. Allow the step motor to cool.

2. Loosen the clamp screw which clamps the step motor in the heat sink. Loosen the set screws in the hub of the sprocket wheel.

3. Slide the step motor away from the panel with one hand. With the other hand catch the sprocket wheel as it comes off the step motor shaft. Burrs on the step motor shaft caused by the sprocket wheel set screws may require some force applied to remove the sprocket wheel.

4. Slide the new sprocket wheel on the shaft as the step motor is pushed in. Push the step motor all the way in its heat sink until it bottoms out against the front panel.

5. Tighten the heat sink clamp screw to hold the step motor in place.

6. Adjust the sprocket wheel and the step motor per paragraph 6.6.2.

9.10. STEPPING MOTOR REPLACEMENT

9.10.1. READER (1, Figure 10.2.)

1. Disconnect power, and remove the unit from the rack if necessary.

2. Remove the step motor leads from TB2.

3. Loosen the set screws in the hub of the sprocket wheel.

4. Loosen the screws which hold the step motor to the front panel.

5. Move the step motor away from the panel with one hand. With your other hand, catch the sprocket wheel as it comes off the end of the motor shaft.

6. Install the new motor and temporarily tighten the mounting screws. Install the sprocket wheel loosely on the motor shaft as you install the motor on the panel.

7. Replace the wires on TB2 per the diagram, Figure 11.1.

8. Loosen the screws holding the motor to the baseplate. Slide the motor up or down until the tips of the sprocket teeth are 0.045" above the surface of the lower tape guide. (See paragraph 6.2., step 1). This adjustment applies both to the horizontal top surface as well as the vertical surface on the right side.

9. Adjust the sprocket wheel as described in paragraph 6.6.1.

9.10.2. READER/REELER (10, Figure 10.6.)

1. Disconnect power, and remove the unit from the rack if necessary.

2. Remove the motor leads from TB2.

3. Loosen the clamp screw which clamps the motor in the heat sink.

4. Loosen the set screws in the hub of the sprocket wheel.

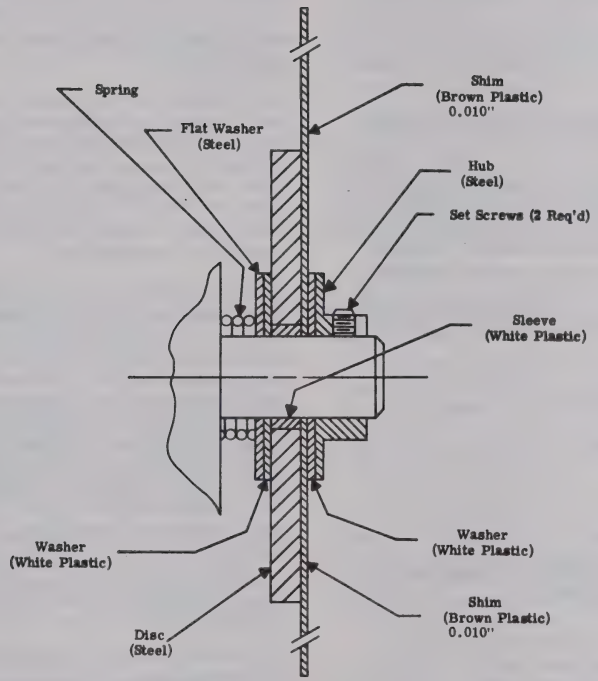


Figure 9.2.
ALIGNMENT OF THE DAMPER ASSEMBLY

5. Slide the motor out of the heat sink with one hand. With your other hand, catch the sprocket wheel as it comes off the end of the motor shaft.

6. Install the new motor in the heat sink, pushing it all the way forward, and tighten the clamp screw. Install the sprocket wheel on the motor shaft as you slide the motor forward.

7. Replace the motor wires on TB2 per Figure 11.1.

8. There should be no need to realign the sprocket wheel in respect to the lower tape guide. However, if it appears necessary, follow the procedure in paragraph 9.10.1, step 8, substituting the heat sink for the motor.

9. Adjust the sprocket wheel as described in paragraph 6.6.2.

9.11. COMPLETE ASSEMBLY AND ADJUSTMENT OF READING HEAD

The following write-up contains a complete description of the assembly and adjustment of the read head. In some cases where certain parts have not been replaced or their alignment has not been disturbed, the procedure concerned with these parts may be skipped.

1. Before starting the alignment, it is necessary to remove the following parts if they have not already been removed:

upper guide tension spring

lamp cover and lower head cover

lamp

lens assembly

Leave the following items in place or mount them loosely if they have been replaced:

flanged tape guide

upper tape guide

solar cell and case assembly

cell case support

step motor

sprocket wheel

2. Center the step motor in its adjustment range.

3. Assemble the lower tape guide and the cell case to the cell case support, and tighten the screws temporarily.

4. Put a 0.030" shim between the cell case and the lower tape guide. Then push the cell case to the right against the guide, and tighten the screws holding the cell case. Remove the 0.030" shim.

5. Using a machine square between the edge of the base plate and cell case support, square the cell case support. Move the assembly sideways so that the openings in the cell case are centered under the slot in the upper tape guide. Also center the support vertically in its adjustment range, and tighten the mounting screws.

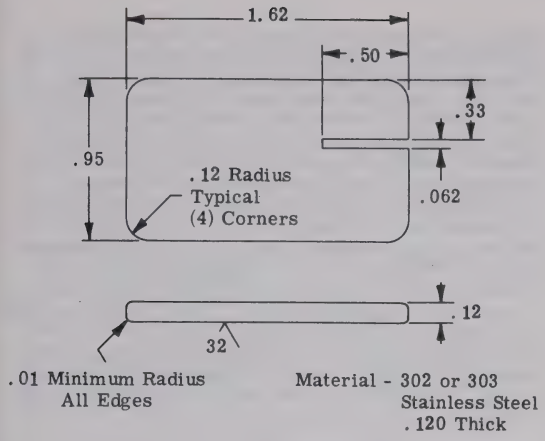
6. Place a machine square along the top edge of the panel so that the straight edge passes through the center of the holes for the lens. The center contact of the lamp socket and the center of the cell apertures in the cell block must be in line with the straight edge. If the cell support needs to be moved right or left, repeat step 5 keeping the support perpendicular to the edge of the base plate.

7. Temporarily remove the upper tape guide and flanged tape guide and then loosen the two screws holding the lower tape guide. Raise the lower guide so that its top surface is in line with the top of the glass plate on the top of the cell case. To accomplish this, place an alignment plate on the cell glass and bring the lower tape guide up to touch the plate. (The alignment plate can be made locally per Figure 9.3. or it can be bought from General Electric Company, Industrial Control Department, as Part Number 44A394941-001). Using a machine square, adjust the lower tape guide so that its top surface is perpendicular to the base plate.

8. Assemble the flanged tape guide temporarily to the base plate.

9. Place a straight edge (alignment plate) across the flanged tape guide, the cell cover glass, and the lower tape guide.

10. Loosen the two screws holding the cell case support, and while maintaining it square with the bottom of the panel (per step 5) and in line under the lens (per step 6), move the assembly up or down so that the top of the cell cover glass and upper surface of the lower tape guide are in line with the top surface of the flanged tape guide. This condition will be obtained when the straight edge touches all three surfaces.



Tolerance of 0.010" on all dimensions unless noted otherwise

Figure 9.3.
ALIGNMENT GAUGE FOR
STEPPING MOTOR READER
ICPD DRAWING NO. 44A394941-001

11. Now remove the flanged tape guide and reassemble it along with the upper tape guide and tension spring for the upper tape guide to the base plate. Install the tension spring for the upper tape guide with the concave side turned toward the base plate.

12. Use a square to check that the surface of the upper tape guide is perpendicular to the base plate and that the underside touches the two spacer buttons on the top of the lower tape guide. If necessary, bend the upper tape guide so that it touches both spacer buttons.

13. Check to see that the gap between the upper tape guide and the flanged tape guide is between 0.010" and 0.018".

14. Check to see that the gap between the cell cover glass and the underside of the upper tape guide is between 0.010" and 0.025".

15. Loosen the screws holding the step motor or its heat sink to the base plate. Slide the motor assembly to position the sprocket wheel so that the sprocket wheel teeth protrude through the slot of the lower tape guide by 0.045 inches, both above and on the right side of the lower tape guide. (See paragraph 6.2., step 1). An 0.045 inch shim can be made from the 0.030 inch (coral) and the 0.015 inch (pink) shims. Tighten the step motor at this position.

16. Position the sprocket wheel so that the tips of the teeth are approximately 1 1/64 inches from the panel and tighten the set screws. Load a tape with all holes punched in each character position. The tape must meet EIA Standard RS-227 for dimensional accuracy. The tape should lie flat across the flanged tape guide and the lower tape guide and be essentially parallel to the panel. If not, then readjust the sprocket wheel until this condition is met.

17. Place the 0.030" shim between the cell and the lower tape guide. Loosen the screws holding the cell and while sighting through the tape, position the cell in and out so that the cell apertures are centered under the holes in the tape. Remove the 0.030" shim after tightening the screws holding the cell case.

18. Install the lamp in the socket so that the long support wire is directly over the filament and the short wire is below the filament per Figure 9.1.

19. With Control power off, unplug the motor drive board (TRD2, TRAD1 or TRAD2 located in the control) to remove power from the stepping motor.

20. Turn on power and check the voltage across the bulb per paragraph 6.3.

21. Put a tape loop with all holes punched in the Reader. Using a 50-microamp meter connected between the cell output and cell common, measure the cell output on track #1. Position the tape for a minimum reading on the meter on track #1.

22. Without moving the tape, measure the current on track #8. Then loosen the screw near track 8 (do not loosen the screw near track #1) and move that end of the cell sideways for minimum reading on the meter. Tighten the screw.

23. Clean the lens assembly and install it. Now position the lens assembly up and down for a minimum width beam at the tape. Then lower the lens until it is nearly the width of a sprocket hole (0.04 inches). Position it sideways in order to center it over the unpunched portion of tape that was positioned in steps 21 and 22. Adjust the lens sideways for a minimum reading on track No. 4.

24. Measure the minimum current on all track cells. They must all be below 15 microamps. If you are unable to obtain this low a current, raise the lens slightly for a narrower beam and repeat the measurement. If it is necessary to reposition the tape in order to get minimum readings at track No. 1 versus track No. 8, then the light beam is at a slight angle. In this case, it may be necessary to replace the lamp or the lens assembly.

25. Use a 1 ma meter (100 ohms or less resistance), position the tape so that a row of holes is over the cell apertures. Position the tape for a maximum reading on the sprocket. Also, loosen the screws holding the lens and check to see that the lens is centered as indicated by a maximum reading. Recheck steps 21 and 22 if the lens is moved much.

26. Measure the maximum current on the sprocket and, with the tape in the same position, measure the current of all tracks. All tracks must be 375 microamps or above, and the sprocket must be 300 microamps or above.

27.1. For the Reader, make a mark with pencil on the sprocket wheel outside surface opposite the two set screws. Then loosen the screws. Turn the wheel around until one of the set screws points down. Turn off power, reinsert the motor drive board and then turn power on. Insert a 0.050-inch hex wrench in the sprocket wheel set screw which is pointing down. Rotate the wheel so that a row of tape holes is over the apertures in the cell. Position the tape for a maximum reading on the sprocket output. Tighten the wheel set screw in this position making sure the conditions of step 16 are met in regards to the tape laying flat on the tape guides. Check that the sprocket cell output is at its maximum at the adjusted position by rotating the sprocket wheel slightly by finger pressure on the wheel. Repeat the adjustment if the peak is off. Turn off power and rotate the sprocket wheel around and tighten the second set screw. Install the upper tape guide detent spring and the lamp and head covers.

27.2. For the Reader/Reeler, turn the power off, reinsert the motor drive board and then turn the power back on. Loosen the two step motor heat sink set screws. Rotate the step motor in its heat sink until a row of holes is over the apertures in the cell. Position the tape for a maximum reading on the sprocket. Making sure the step motor is pushed all the way in the heat sink, tighten the set screws to a torque of 5.5 lb-in. Turn power off, remove the tape, and see if the step motor spins freely. If it does not, reduce the set screw torque to 5.0 lb-in. minimum. Recheck the spin of the step motor. If it still does not spin freely, replace the step motor. Turn power back on and reinstall the punched tape. Check that the sprocket cell output is at its maximum at the adjusted position by rotating the sprocket wheel slightly by finger pressure on the wheel. Repeat the adjustment if the peak is off. Turn off power and install the upper tape guide detent spring and the lamp and head covers.

9.12. ARM TENSION SPRING (2, Figure 10.5.)

1. Grasp the spring and free it from the sheet metal hook.

2. Loosen the set screw holding the spring lever (14, Figure 10.7.) to the tape tension arm shaft. Back off the set screw several turns to move it away from the flat on the shaft at this point.

3. Rotate the spring lever on the shaft until the dowel pin holding the pulley is exposed. Drive out the pin and remove the pulley.

4. Place the pulley in the end of the new spring and reassemble the pulley in the spring lever.

5. Rotate the spring lever until the set screw is opposite the flat on the shaft. The spring lever should be moved lengthwise along the shaft so that the spring is approximately parallel to the front panel but the set screw is still on the flat on the shaft.

6. Grasp the spring and hook the end in the sheet metal hook.

9.13. RSF1 BOARD-FEEDBACK SENSOR ASSEMBLY (11, Figure 10.7.)

1. Remove the cover from the feedback assembly.

2. Remove the cable from the RSF1 printed-circuit board.

3. Remove the 4 screws holding the base (13, Figure 10.7.) to the bearing support (4, Figure 10.7.). Slide the unit sideways so that the shutter will not be damaged.

4. Install the new unit by reversing the above procedure.

5. Readjust the shutter per paragraph 6.10.

9.14. BROKEN TAPE SWITCH REPLACEMENT (2, Figure 10.6.)

1. Unbolt the switch from the bracket.

2. Unsolder the wires leading to the switch that has to be replaced. Tag the wires as they are removed.

3. Connect the wires to the new switch.

4. Mount the switch on the bracket.

5. Adjust the switch per paragraph 6.11.

9.15. REEL MOTOR REPLACEMENT (10, Figure 10.4.)

1. Make a note of the motor wire lead polarity and connection. Then remove the wires.

2. Support the motor from the back and remove the 2 screws holding the motor to the front panel. Remove the motor.

3. Mount the new motor in place on the panel. Tighten the 2 motor mounting screws.

4. Replace the wires as noted in step 1 above.

5. Turn the power on and move the tape tension arm back and forth through its range of travel so that the new motor will run. Check the rotation of the new motor in the various zones per paragraph 6.10., step 2 or 3.

6. If the direction of motor rotation is incorrect, shut off power and reverse the leads at the terminal board and recheck.

7. When the direction of rotation is correct, check the brake torque per paragraph 6.9.

9.16. REEL BRAKE ASSEMBLY REPLACEMENT (2, Figure 10.4.)

1. Remove power from the unit, and put the tension arm in its load clip.

2. Loosen the two set screws and slide the brake assembly off of the reel hub.

3. Inspect the brake facing for signs of damage or worn-through condition, and replace it, if necessary, per paragraph 9.17.

4. Install the new brake assembly by reversing the procedure of step 2 above.

5. Adjust the new brake assembly per paragraph 6.9.

9.17. REEL BRAKE FACING REPLACEMENT (2, 10, Figure 10.4.)

1. Remove power from the unit.

2. Loosen the two set screws and remove the brake assembly per paragraph 9.16.

3. Remove the facing material by sliding a knife or other suitable instrument under the edge and pulling the material up. Make sure all pieces of the material are removed.

4. Clean the surfaces with isoprophyl alcohol.

5. Remove the paper backing material from the new facings.

6. Slide one new facing down over the shaft and attach it to the face of the motor so that the facing material is centered concentrically around the motor shaft. Similarly affix the other facing to the brake assembly.

7. Apply finger pressure to glue the facing material to the surfaces, making sure that there are no bulges or creases in the material.

8. Replace the brake plate assembly and tighten the set screws.

9. Adjust the brake torque per paragraph 6.9.

10. Apply power to the unit and allow the brakes to run in for approximately 30 minutes.

11. Repeat steps 9 and 10 until the brake torque stabilizes.

9.18. TENSION ARM ASSEMBLY REPLACEMENT (9, 20, Figure 10.4.)

1. Remove power from the unit.

2. Release the tension spring per paragraph 9.12.

3. Loosen the clamp screw holding the arm to the shaft, and remove the arm.

4. Remove the clamp screw and nut from the old arm and install it on the new arm.

5. Install the replacement arm on the feedback assembly shaft and tighten the clamp screw.

6. Swing the arm through its full length of travel. Check that it does not scrape the panel and that it passes behind the fixed guide roller support at the edge of the panel and snaps into the arm loading clip.

7. Reinstall the tension spring and check the shutter adjustment per paragraph 6.10.

9.19. ROLLER REPLACEMENT (2A, 5B, Figure 10.3.; 9B, Figure 10.4.)

1. Remove the snap ring on the end of the shaft.

2. Slide the roller (and item 5B bearings) off the shaft.

3. Inspect the shaft for scoring or other damage. Replace the shaft (paragraph 9.20.) if it is damaged or scored.

4. Replace the new roller on the shaft and replace the snap rings.

5. Check the roller to see that it turns freely.

9.20. ROLLER SHAFT REPLACEMENT

A. Single roller shaft (5A, Figure 10.3.).

1. Remove the roller per paragraph 9.19.

2. Remove the old roller shaft by removing, on the back of the panel, the screw holding the part in place.

3. Place the new roller shaft on the panel, and replace the holding screw from the back of the panel. Tighten the screw securely.

4. Replace the roller per paragraph 9.19.

B. Three Roller Assembly (2, 8, Figure 10.3.)

If the fixed guide roller shafts are scored and require replacement, it is recommended that the entire assembly including rollers, etc. be replaced.

1. Remove the tape from the unit.

2. Remove the 3 screws holding the roller assembly to the panel.

3. Using the same 3 screws, attach the replacement roller assembly to the panel.

9.21. TENSION ARM ROLLER SHAFT REPLACEMENT (9A, 20A, Figure 10.4.)

If the arm roller shafts are scored and require replacement, it will be necessary to replace the entire tension arm assembly. Refer to paragraph 9.18. for the proper procedure.

9.21. REEL SHAFT REPLACEMENT (10B, Figure 10.4.)

1. Remove the brake assembly (2, Figure 10.4.) per paragraph 9.16.

2. Remove the reel shaft assembly by loosening the 2 set screws.

3. Install the new reel shaft assembly and position the shaft such that the distance from the front surface of the thick part of the hub to the reel motor surface is 0.875 ±.01 inches. Tighten the set screws.

4. Replace and adjust the brake assembly per paragraph 9.16.

9.22. TENSION ARM SHAFT AND BEARING REPLACEMENT (3, 5A, 5B, Figure 10.6.)

In the following description refer to Figure 9.4.

1. Remove power from the unit. To replace the front bearing, go to step 2. To replace the rear bearing, go to step 7.

2. Unhook the tension spring, and remove the tension arm per paragraph 9.18.

3. Remove the screws which hold the bearing block to the front panel.

4. On the front of the bearing block, remove the snap ring from the shaft. Remove the spacer and the bearing.

5. Install the new bearing, spacer and snap ring. Remount the bearing block on the front panel.

6. Replace the tension arm and tension spring following the instructions of paragraph 9.18.

7. To remove the rear bearing, first remove the feedback assembly cover and unhook the tension spring.

8. Remove the shutter support block.

9. Cut away the retaining ring and remove the spacer and rear bearing.

10. Install the new bearing, spacer, new retaining ring and shutter support block.

11. Hook the tension spring. Adjust the shutter per paragraph 6.10.

12. To replace the shaft, combine the two bearing replacement procedures.

9.23. REEL SHAFT "O" RING REPLACEMENT (10, Figure 10.4.)

The preferred "O" ring for replacement for better service and longer life is General Electric part no. 44A710027-001. Serviceable "O" rings can be purchased in hardware stores. The essential dimensions are an outside diameter of 1/2 inch and a 1/16-inch cross section made of Buna N rubber.

1. To remove the "O" ring, start it out of its groove with long nose pliers and then roll it off the shaft.

2. Clean the reel hub with isopropyl alcohol to remove the reel material which has powdered. Also clean the reels of this powder so that the "O" ring can get a better grip on the reel.

3. Roll the new "O" rings on the shaft and fully seat them in the grooves. Take a reel and carefully install it on the reel hub to check that the "O" rings have seated properly.

9.24. REEL MOTOR BRUSH REPLACEMENT (10, Figure 10.4.)

1. Disconnect power from the unit.

2. Unscrew the two brush caps and remove the brushes.

3. Insert the new brushes and replace the caps.

4. Turn on power and let the motor run for one-half to one hour to seat the brushes.

9.25. RUN-LOAD SWITCH REPLACEMENT (3, Figure 10.5.)

1. Remove the wires from the defective switch and label each wire as it is removed.

2. The Run/Load switch is mounted on the reeler power supply subassembly with the toggle only protruding through the base plate. To gain access to the switch lock nut, the subassembly will have to be loosened from the base plate. Four screws hold the subassembly to the base plate. First, loosen the two lower screws which go through the transformer T2 mounting feet. Next, remove the two screws which go through the subassembly weld nuts and carefully tilt the subassembly back.

3. Remove the switch locknut and switch. Install the new switch.

4. Remount the subassembly to the base plate.

5. Reconnect the switch wires and check for proper operation per paragraph 4.14.

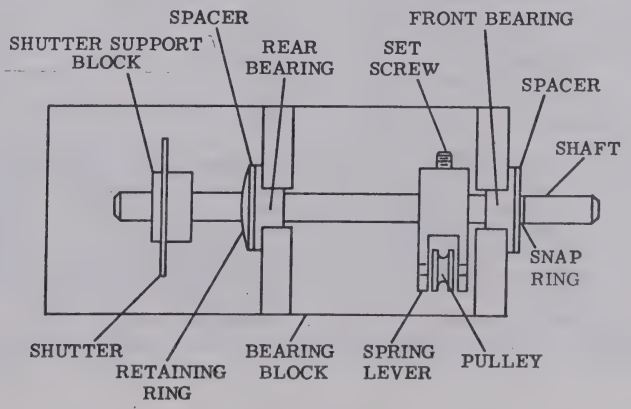


Figure 9.4.
TENSION ARM SHAFT BEARING ASSEMBLY REMOVED FOR BEARING REPLACEMENT

SECTION 10
PARTS LIST

10.1. INTRODUCTION

This section contains a Parts List which is divided into the following two sections:

1. Reader-Assembly Number 44D232560-G01

2. Reader/Reeler-Assembly Number 3N3200TR103B1

The columns on the Parts List contain the following information:

1. Figure and Index Number - A key to locate an individual illustration and detail part on the illustration.

2. Part Number - The General Electric or manufacturer's part number.

3. Description - Nomenclature of the part and modifiers necessary to identify the particular item for reordering (i.e., resistance value, capacitance, dimensions, reference designations, etc.)

4. Units per Assembly - The number of units required per assembly or subassembly.

10.2. PROCEDURE FOR ORDERING PARTS

To order a replacement part:

1. Refer to the Parts List to determine the actual name and number of the part.

2. Give full descriptive data of the item or items as well as the part number of the item. Also give the assembly number and serial number of the tape reader and the GEK number on the front of this book.

3. Address orders to the nearest Apparatus Sales Office of the General Electric Co. or the nearest I & SE office.

PARTS LIST FOR READER (ASSEMBLY NUMBER 44D232560-G01)

FIGURE AND INDEX NO.	PART NUMBER	DESCRIPTION	UNITS PER ASSEMBLY
5-1, -2	44A394909-G01	Lamp Cover Assembly	1
-3	44A394908-001	Cover, Lower	1
10-1, -1	44B395262-001	Base Plate	1
-2	44A394901-001	Guide, Lower	1
-3	44A417068-002	Spring Washer, Upper Tape Guide	1
-4	44A393665-002	Sprocket Wheel	1
-5	44A393675-001	Stud, Ball	2
-6	44A393676-001	Spring, Tension, Upper Guide	1
-7	44A394900-001	Guide, Upper	1
-8	44A397735-G01	Lens Assembly	1
-9	44B387921-G04	Cell/Cable Assembly	1
-10	44A394902-001	Support, Cell Case	1
-11	44A393666-001	Lamp	1
-12	44A394903-001	Guide, Tape, Flanged	1
-13	44A394912-001	Clip	1
-14	44A397929-001	Teflon Washer, Upper Tape Guide	1
-15	44A397736-003	Plate	1
10-2, -1	44A393669-001	Stepmotor with Damper	1
-2	124A1898C10	Resistor, 1.00 ohms, 10 watts, 1% Tol.	1
-3	44A393669-002	Damper Assembly Only	1
-4	44B211519-020	Terminal Board	2
-5	44A393667-001	Holder, Lamp	1
-6	44A394986-001	Spacer, Lamp	2
-7	K9774710P7	Washer, Shoulder	4
-8	44B230672-G06	Standoff Insulator	2

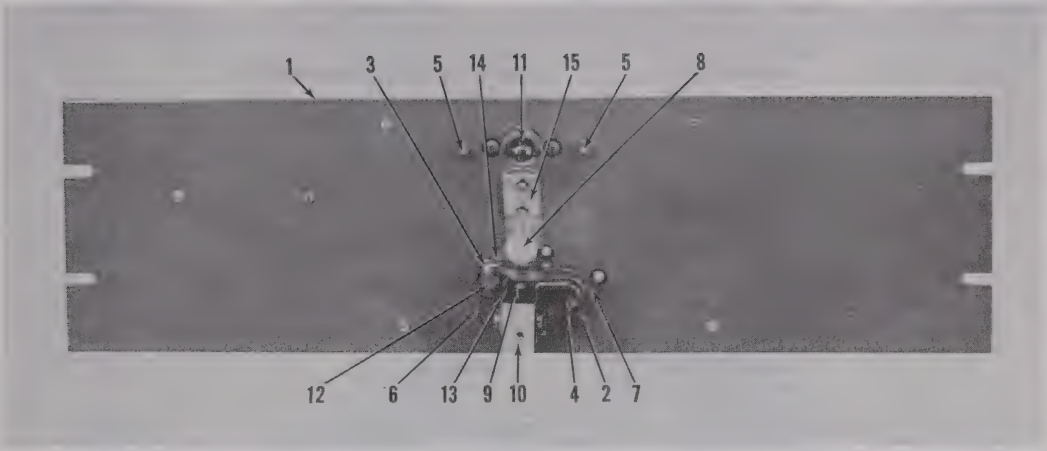


Figure 10.1.
READER
FRONT VIEW PARTS LOCATION

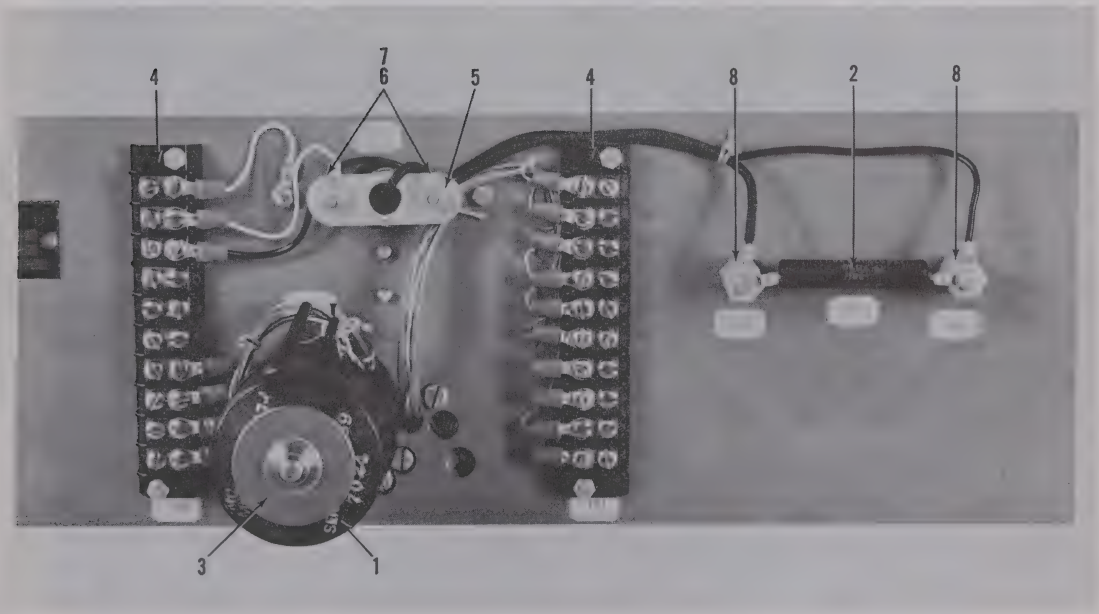


Figure 10.2.
READER
REAR VIEW PARTS LOCATION

Ref. 73-011
Ref. 70-090

PARTS LIST FOR READER/REELER (ASSEMBLY NUMBER 3N3200TR103B1)

FIGURE AND INDEX NO.	PART NUMBER	DESCRIPTION	UNITS PER ASSEMBLY
10-3, -1	44A393691-001	Reel	1
REF	44A393691-002	Empty Core to fit 44A393691-001 Reel	
-2	44A397777-G04	Roller Assembly, Right Hand	1
-2A	44A397778-001	Roller	2
	N910P21C	Snap Ring	2
-2B	44A394905-001	Roller	1
	44A393673-001	Bearing, Ball	2
	44A399629-001	Spacer	1
	N910P18C	Snap Ring	1
-3	44A397760-G01	Spacer Assembly with Arm Clip	2
-4	44A393696-001	Bumper, Rubber	2
-5	44A394904-G02	Roller Assembly	2
-5A	44A394906-001	Spindle	1
-5B	44A394905-001	Roller	1
	44A393673-001	Bearing	2
	N910P18C	Snap Ring	1
-6	44A394908-001	Cover, Lower	1
-7	44A394909-G01	Lamp Cover Assembly	1
-8	44A397777-G03	Roller Assembly, Left Hand	1

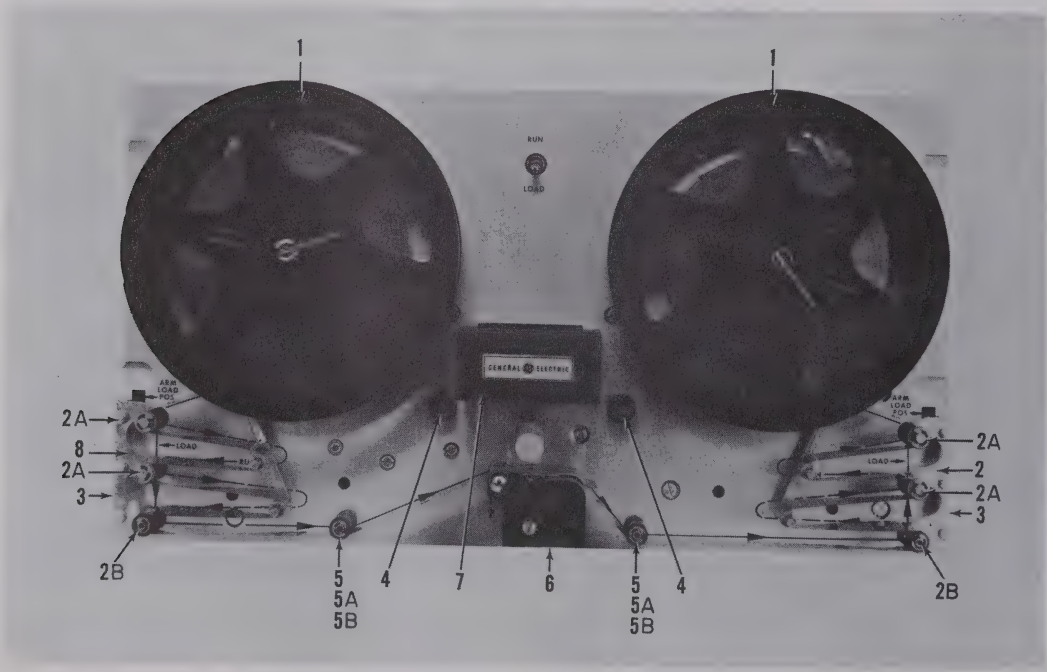


Figure 10.3.
READER/REELER
FRONT VIEW

PARTS LIST FOR READER/REELER (ASSEMBLY NUMBER 3N3200TR103B1)

FIGURE AND INDEX NO.	PART NUMBER	DESCRIPTION	UNITS PER ASSEMBLY
10-4, -1	44C394253-001	Base Plate	1
-2	44A394915-G01	Brake Assembly	2
-2A	44A397700-001	Disc	1
	44A394917-001	Diaphragm	1
	44A394918-001	Hub	1
	44A393693-002	Spring	4
	44A394938-001	Brake Lining	1
-3	44A393675-001	Stud, Ball	2
-4	44A397735-G01	Lens Assembly	1
-5	44B218551-005	Switch, Toggle	1
-6	44A393667-001	Lamp Holder	1
-8	44A393666-001	Lamp	1
-9	44A397781-G02	Tape Tension Arm, Right Hand	1
-9A	44B396232-G02	Arm and Spindles	1
-9B	44A397778-002	Roller	2
	N910P18C	Snap Ring	4
-10	44A394943-G02	Motor Assembly	2
-10A	44A393687-004	Reel Motor	1
-10B	44A394940-G01	Reel Shaft Asm.	1
	44A394938-001	Brake Lining	4
	44A710027-001	O Ring (Parker Seal Company)	4
	44A395937-006	Replacement Brush	*
	44A395937-002	Replacement Brush Cap	*
-11	44A394901-001	Lower Tape Guide	1
-12	44A393665-002	Sprocket	1
-13	44A394902-001	Head Support	1
-14	44A394912-001	Clip	1
-15	44B387921-G10	Cell/Cable Assembly	1
-16	44A394903-001	Tape Guide, Flanged	1
-17	44A393676-001	Spring, Tension, Upper Guide	1
-18	44A394900-001	Upper Tape Guide	1
-19	44A417068-002	Spring Washer, Upper Tape Guide	1
-20	44A397781-G01	Tape Tension Arm, Left Hand	1
-20A	44B396232-G01	Arm and Spindles	1
-22	44A393696-001	Bumper, Rubber	2
-23	44A397736-003	Plate	1
-24	44A397717-001	Key	1
-25	44A397929-001	Washer, Teflon, Upper Tape Guide	1

*Order quantity 2 per motor for replacement.

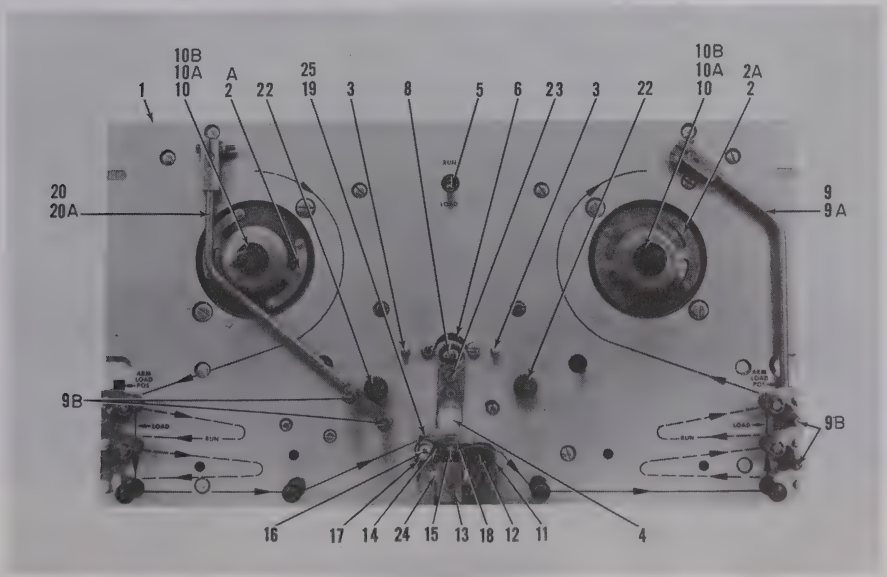


Figure 10.4.
READER/REELER
FRONT VIEW WITHOUT REELS

PARTS LIST FOR READER/REELER (ASSEMBLY NUMBER 3N3200TR103B1)

FIGURE AND INDEX NO.	PART NUMBER	DESCRIPTION	UNITS PER ASSEMBLY
10-5, -1	44B396195-G01	Feedback Assembly, Right Hand	1
-1A	44A397074-001	Cover	1
-2	44A393694-002	Spring	2
-3	44B218551-005	Switch, Toggle, Run/Load	1
-6	44B396195-G02	Feedback Assembly, Left Hand	1
-6A	44A397074-001	Cover	1
-8	44A398793-G01	RSD3 Printed Circuit Board	1
-9	44B211519-020	Terminal Board	3
-10	44B396233-001	Bracket	1
-11	44A212119-001	Fuse Holder	1
-12	K9774741P13	Fuse, 1 amp, 250 volt, slow blow	1
-13	44B232204-013	Bushing, Nylon	5
-14	44B396189-001	Bracket, P.C. Board Support	1

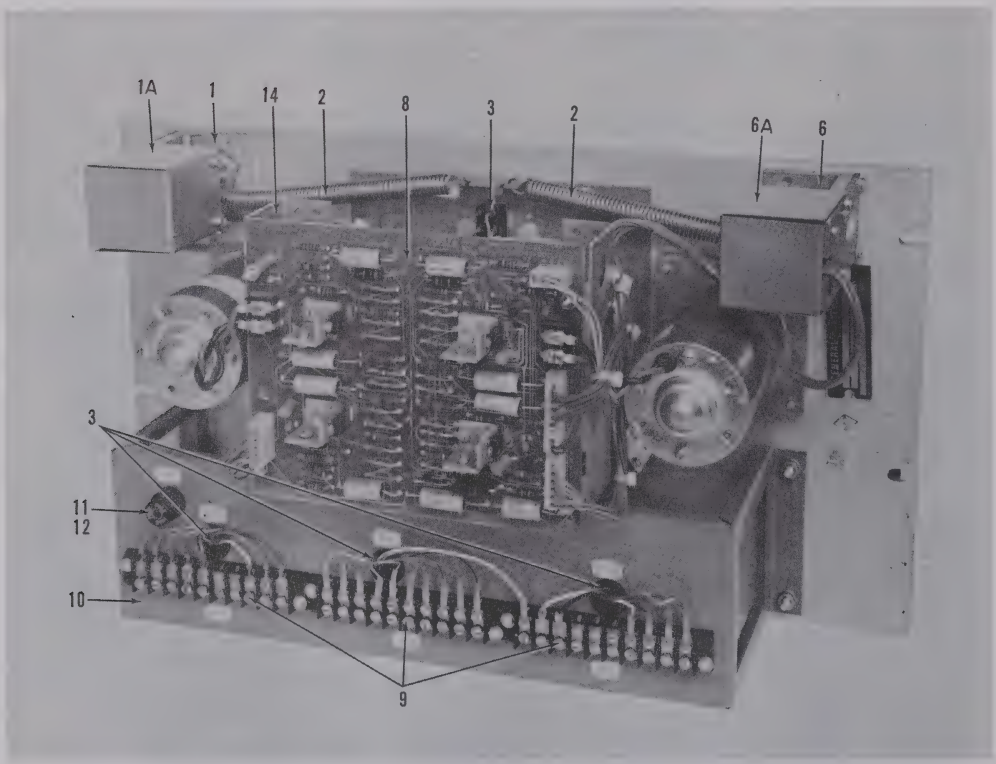


Figure 10.5.
READER/REELER
REAR VIEW

PARTS LIST FOR READER/REELER (ASSEMBLY NUMBER 3N3200TR103B1)

FIGURE AND INDEX NO.	PART NUMBER	DESCRIPTION	UNITS PER ASSEMBLY
10-6, -1	44A396188-003	Bracket, Power Supply Assembly	1
-2	44A399602-001	Switch, Tape Break	2
-3	44B396233-003	Bracket	1
-4	44B396233-004	Bracket	1
-5	44A393667-001	Holder, Lamp	1
-6	44A394986-002	Spacer	2
-7	K9774710P7	Washer, Shoulder	4
-8	K8622212C10	Resistor, 1.00 ohms, 10 watts, 5% Tol.	1
-9	289A619P1	Insulator, mica	2
-10	44A393669-001	Stepmotor with Damper	1
-11	44A397797-001	Heat Sink	1
-12	44A393669-002	Damper Assembly Only	1
-13	44B398016-001	Transformer T2	1

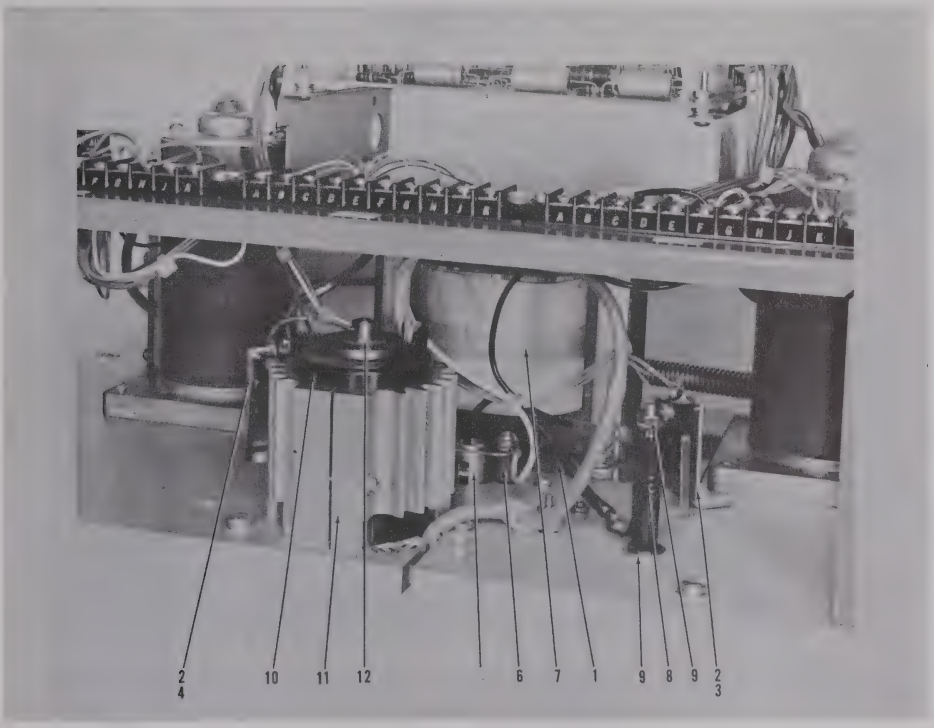


Figure 10.6.
READER/REELER
LOWER REAR VIEW

PARTS LIST FOR READER/REELER (ASSEMBLY NUMBER 3N3200TR103B1)

FIGURE AND INDEX NO.	PART NUMBER	DESCRIPTION	TOTAL UNITS
10-7, -1	N900P25C	Snap Ring	1
-2	44A710068-001	Shaft Spacer	2
-3	44A710069-001	Bearing	2
-4	44A397784-001	Bearing Support	1
-5A	44A397073-001	Shaft, Right Hand Feedback Assembly	1
-5B	44A397073-002	Shaft, Left Hand Feedback Assembly	1
-6	44A397072-003	Plate	1
-7	44A397072-002	Plate	1
-8	44A397799-002	Shutter	2
-9	44A397072-001	Shutter Support	1
-10	N531P1005B	Drive Pin	2
-11	44A398794-G01	RSF1 Printed-Circuit Board	1
-12	44A394964-006	Spacer	4
-13	44A397075-001	Base	1
-14	44A394928-001	Spring Lever	1
-15	44A394934-001	Roller	1
-16	44B211535-013	Retaining Ring	1
-17	N533P608C	Roll Pin	1
-18	N533P604C	Roll Pin	1

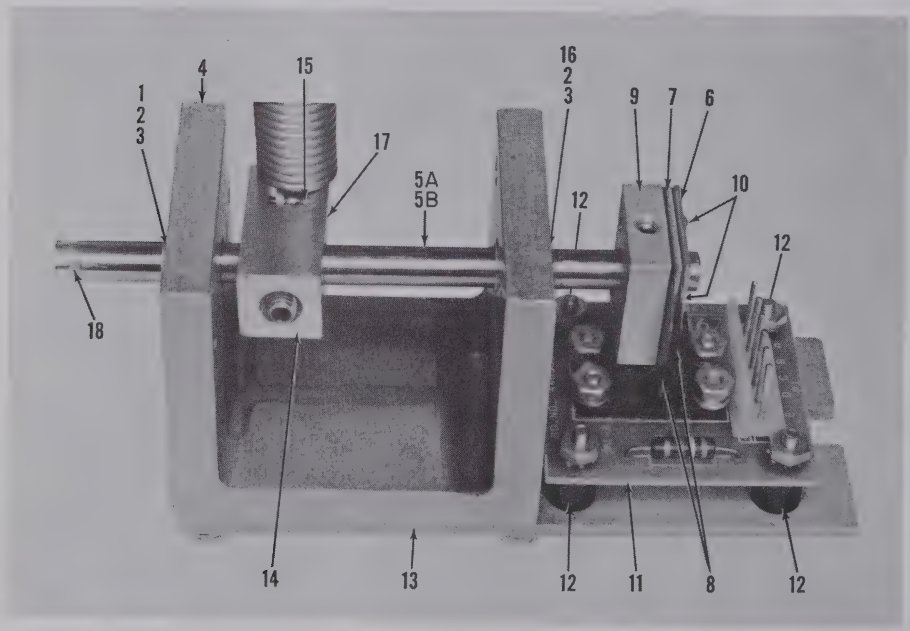


Figure 10.7.
READER/REELER FEEDBACK ASSEMBLY

SECTION 11
DRAWINGS

11.1. CONTENTS

This section contains the following drawings:

Figure 11.1. Reader, Assembly No. 44D232560-G01, Drawing No. 44C388079.

Figure 11.2. Schematic of the Reader Portion of the Reader/Reeler, Assembly No. 3N3200TR103B1, Drawing No. 44C382638, Sheet 1.

Figure 11.3. Schematic of the Reeler Portion of the Reader/Reeler, Drawing No. 44C382638, Sheet 2.

MARK CENTURY
TAPE READER
MØDEL 44D232560-G01

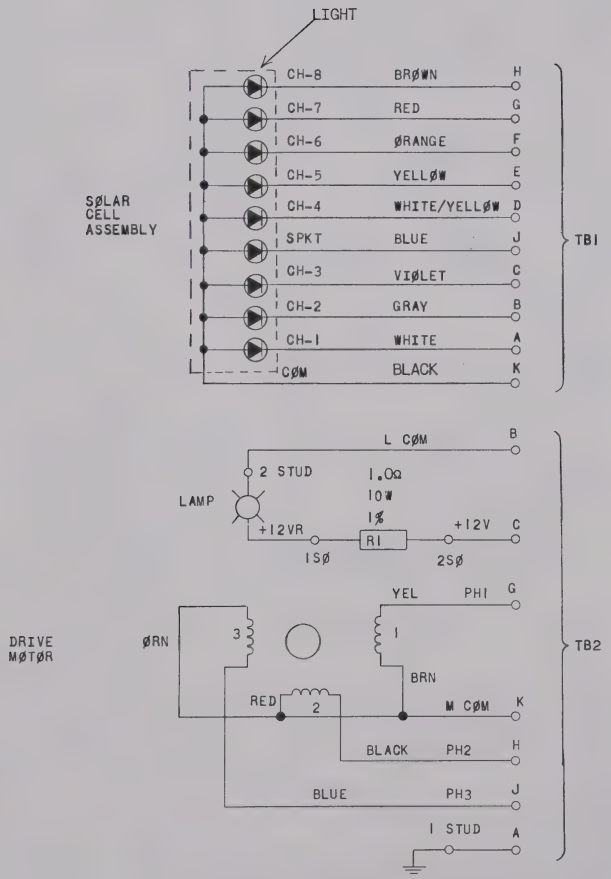


Figure 11.1.
SCHEMATIC OF THE READER,
ASSEMBLY NO. 44D232560-G01

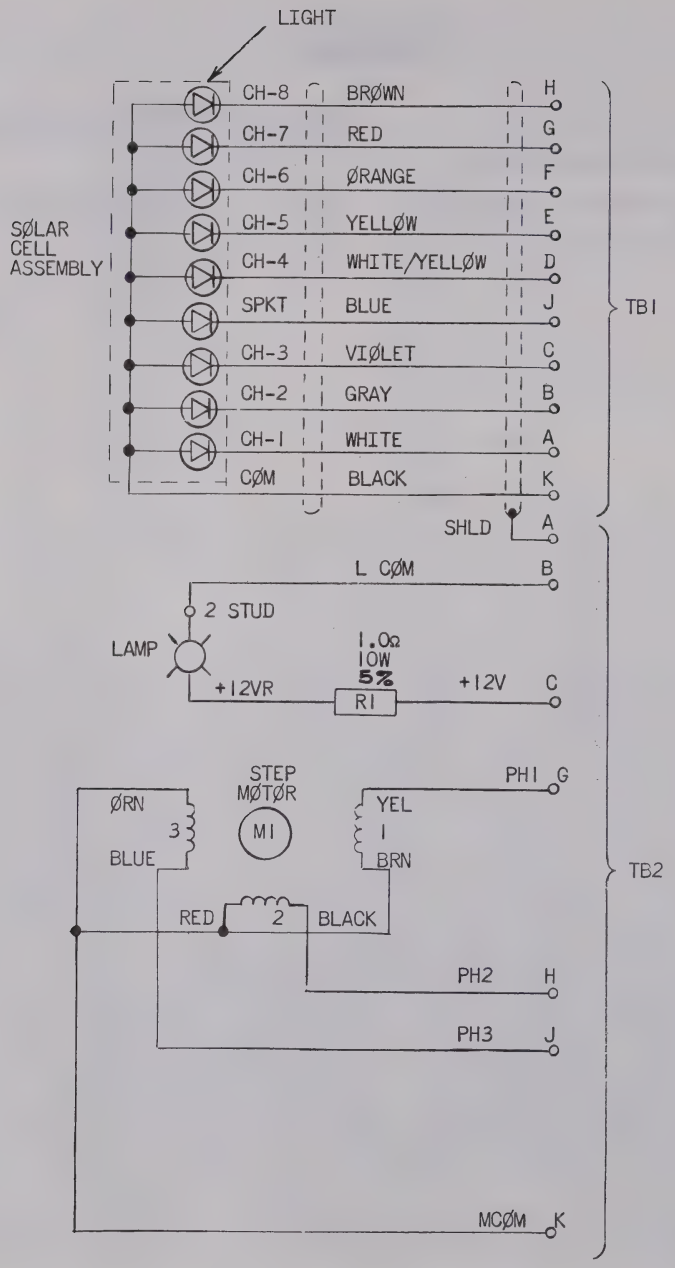


Figure 11.2.
SCHEMATIC OF THE READER PORTION
OF THE READER/REELER
ASSEMBLY NO. 3N3200TR103B1

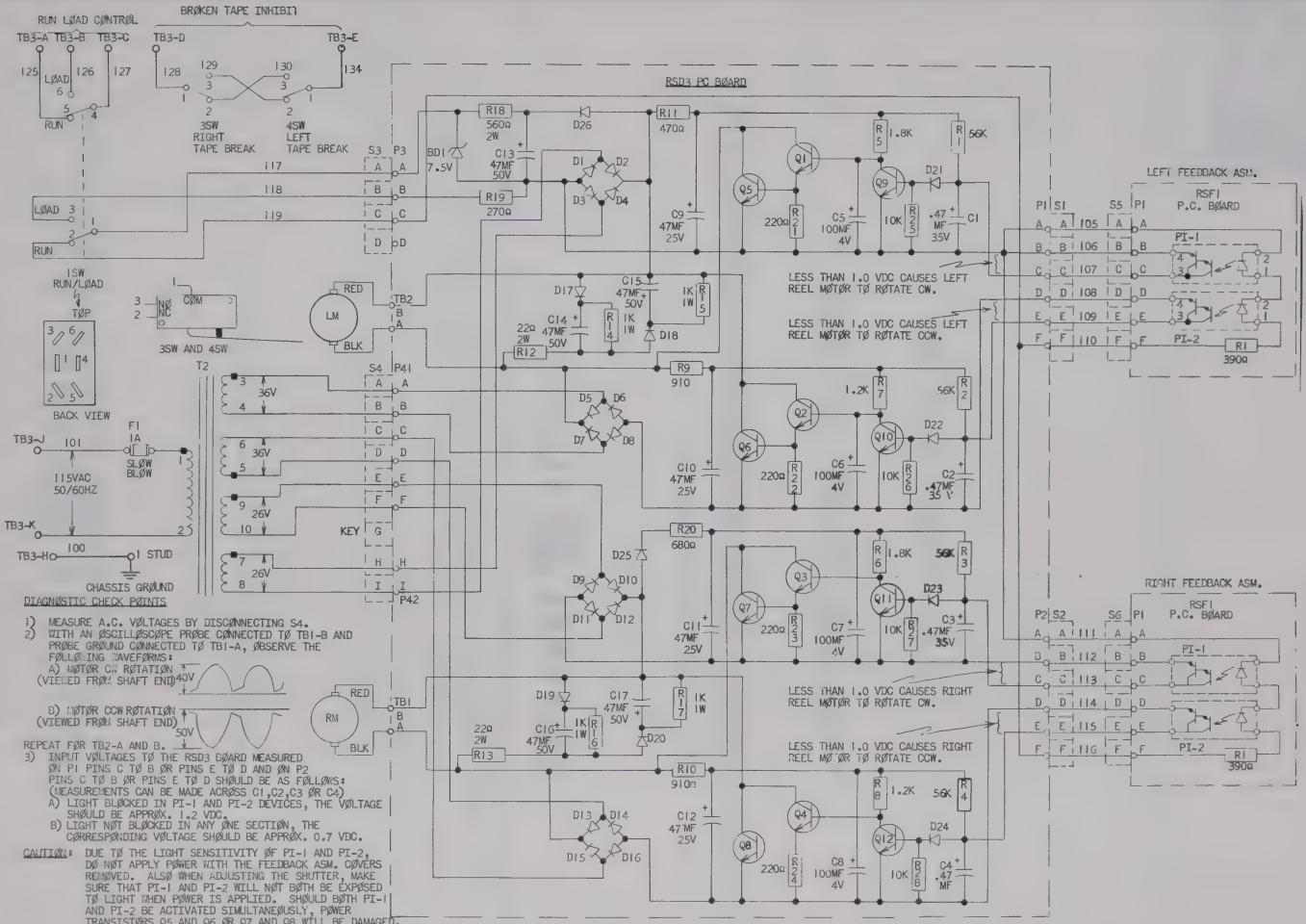


Figure 11.3.
SCHEMATIC OF THE REELER PORTION
OF THE READER/REELER
ASSEMBLY NUMBER 3N3200TR103B1

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Waynesboro, Virginia 22980

GENERAL ELECTRIC

INDUSTRIAL CONTROL DEPARTMENT, GENERAL ELECTRIC COMPANY, WAYNESBORO, VIRGINIA

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GEK-45669A

INSTRUCTIONS

MARK CENTURY*

150-CPS TAPE REELER

ASSEMBLY NUMBER 3N3200TR104A1

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GENERAL ELECTRIC

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NOVEMBER, 1978

SECTION 1
DESCRIPTION OF EQUIPMENT

1.1 GENERAL DESCRIPTION

This Instruction Book covers the 150-CPS Tape Reeler (3N3200TR104A1). The Reeler is specifically designed to operate in conjunction with the 150-CPS Tape Reader (44D232560-G01) and is rack-mounted directly below the Reader. The Reader is described in any of the following instruction books: GEK-29852, GEK-45562, or GEK-45650. The Reeler is manufactured by the Industrial Control Department of the General Electric Company, Richmond, Virginia, USA, for use in Mark Century* Controls.

This book contains the following sections: General Description, Specifications, Installation, Theory of Operation, Operation, Checks and Adjustments, Preventive Maintenance, Troubleshooting, Parts Removal and Replacement, Parts Lists, and Drawings.

The Reeler is shown in Figure 1.1. It is capable of handling all tapes specified for the 150-CPS Tape Reader. The Reeler is self-contained with no electrical interconnections with the Reader. It supplies and takes up tape automatically in response to the Reader demands in both forward and rewind directions.

The Reeler is supplied with two-5 1/4-inch diameter reels, each reel capable of holding up to 375 feet of tape. The self-locking reel hubs are one-half inch in diameter and accept standard** plastic reels for 1-inch tape. The reel motors are special shaded pole AC motors driven in a torque opposition manner. A toggle switch provides the Reeler functional operation with a center OFF/LOAD position to remove motor power, an upper RUN position for normal Reader operation and a lower MANUAL REWIND position for rapidly rewinding tape. The panel or base plate is designed for standard rack mounting beneath the Reader. Figure 1.2 shows the normal mounting of the Reeler in conjunction with the Reader. Only 3 external electrical connections are required to operate the Reeler, 2 for 115 VAC and 1 for chassis ground.

Additional information regarding performance as well as operating, electrical, and physical characteristics is contained in the following sections.

* Trademark of General Electric Company, USA.
** USASI Standard: USAS x3.20 - 1967

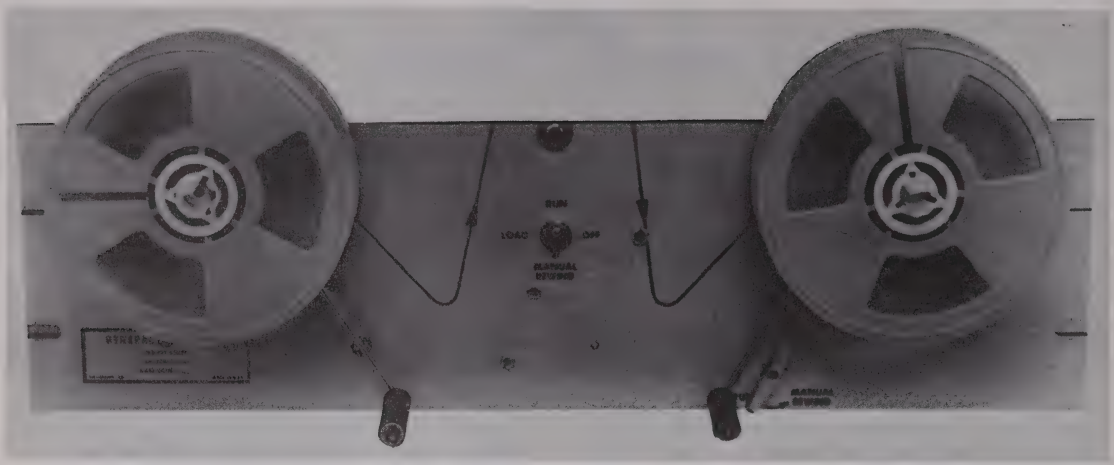


Figure 1.1
150-CPS REELER (3N3200TR104A1)

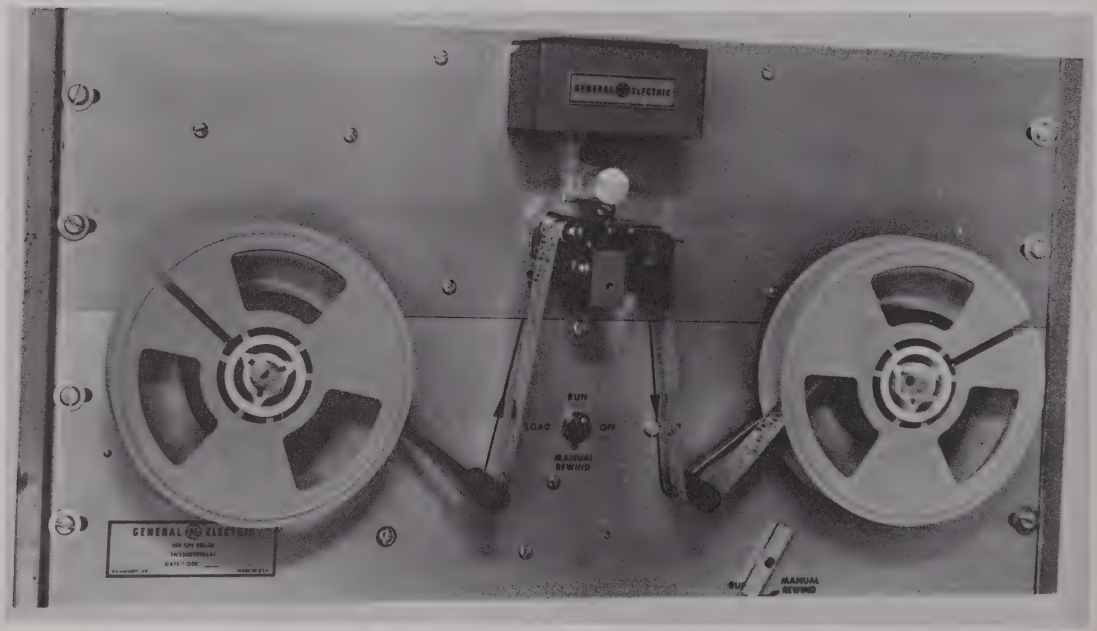


Figure 1.2
READER/REELER RACK-MOUNTED CONFIGURATION

Ref. 761-16-0801
Ref. 761-16-0800

SECTION 2
SPECIFICATIONS

2.1 REELER SPECIFICATIONS

The specifications for the 150-CPS Reeler are provided below:

Table 2.1

Reeling direction	Bidirectional - follows the Reader in forward and rewind.
Normal speed	Compatible with Reader (150-CPS forward, 235-CPS rewind.)
Manual rewind	Equivalent to 1500-CPS average for full reel of tape.
Tape	Standard 1-inch tape as specified for the Reader with a 5-foot leader at the beginning and end of the program tape for properly threading to the reels.
Tape life	In conjunction with a properly adjusted Reader: Mylar-aluminum laminate-50,000 passes black paper - 500 passes
Reels	The reel motor self-locking hubs are designed to hold reels with 1/2-inch I. D. hubs per USASI Standard x3.20 - 1967. The supplied reels have an O. D. of 5 1/4-inch with a capacity of 375 feet of tape. For greater tape capacity, 6-inch O. D. reels may be used for up to 500 feet of tape; however, the Reeler cycle operation will not be as smooth because of the increased inertia. In 1050 Controls where lengthy "system software" tapes are sometimes necessary, 7 1/2-inch reels with capacity up to 800 feet of tape may be used. These reels should only be used for constant data rate input, not for cycle operation because of sluggish reeler response due to the much increased inertia.
Dimensions: Height	5 1/4 inches
Width	19 inches
Depth	3 1/4 inches from panel to the rear of the unit. 2 5/8 inches from the mounting surface forward.
Weight	9 pounds
Power requirements: Voltage	115 VAC +10%, -15% 50/60 Hz
Current	.86 amp (60 Hz), .95 amp (50 Hz)
Power	62 watts (60 Hz), 76 watts (50 Hz)
Fuse	2 amp
Temperature	0 to 65°C

SECTION 3
INSTALLATION

3.1 UNPACKING

Normally the Reeler is shipped assembled and mounted in the Control. When the Reeler is shipped separately, exercise care in handling and opening the carton. Primarily use the Reeler panel for lifting and handling. Do not use the tension arms or motor hubs for lifting to avoid misalignments. Remove all ties or rubber bands used to constrain the tension arms during shipment. Prior to installing the Reeler, make a visual inspection for signs of damage that may have occurred during transit (Table 3.1 provides a convenient guide for this inspection). If any apparent damage exists as a result of shipping, it should be reported to the carrier immediately. The General Electric Company should also be notified.

Table 3.1
VISUAL CHECKS FOR SIGNS OF DAMAGE

ITEM	CHECK
Panel	All components are tightly secured to the front panel, there is no evidence of damage, and the general alignment is visually correct.
Electrical Wiring	There is visible continuity, and there are no broken wires.
Electrical Components	Terminal board or resistor is not broken.
Motors	Each motor is securely mounted. With the tension arms lifted, the motors rotate freely in each direction and the reel hubs do not have excessive wobble.
Fuse	The fuse receptacle is tightly secured to the panel, electrical connections are intact, the fuse is properly seated and is of the proper value (2 amp).
Switch	The switch is securely mounted on the panel, all connections intact, mechanical operation is correct, and markings are legible.
Noise Filters	The 2 electrical noise filters are firmly adhered to the panel and the connections into the terminal board are intact.
Tension Arms	The tension arms move smoothly against the spring tension. Note a change in tension when the arm is raised approximately 2 1/4 inches above the bottom edge of the panel. The arms show no unusual bends, are parallel to and do not touch the panel. The rollers rotate freely and are essentially perpendicular to the panel.
Reels	The reels are intact and seat properly on the reel hubs.

3.2 MOUNTING INSTRUCTIONS

The Reeler is specifically designed to be used in conjunction with the 44D232560-G01 Reader and is mounted on the standard 19-inch equipment rack directly below the Reader. Two spacer bars (44B395409-002) are provided with the Reeler which space both the Reader and Reeler out equidistantly from the rack mounting surface so they are both in line over the tumble box. After mounting and, if necessary to align the Reader and Reeler panels because of warpage, a screw with double washer is provided with the Reeler to clamp the 2 panels to each other at the center. This clamping may be necessary to maintain proper alignment between the 2 units so that the tape will run true through the read head and on the rollers.

Figure 3.1 (Installation Diagram 44C285818) shows the details of the installation including those steps necessary for the field installation of the Reeler option. Once the Reeler has been installed, check that the tension arm restraining springs on the back of the unit are resting properly on their respective pins. See Figure 10.2.

3.3 POWER AND INTERFACE DATA

The only power required from the Control to run the Reeler is 115 volts AC, 50/60 Hertz at a current of .86 amps (60 Hz) or .95 amps (50 Hz). There are only three Reeler/Control interface connections, all made through TB3 on the back of the Reeler. These are identified in Table 3.2.

Table 3.2
REELER/CONTROL INTERFACE

PIN	CONNECTION
TB3-B	115 VAC (Hot)
TB3-C	115 VAC (Neutral)
TB3-E	Chassis Ground

There are no electrical interconnections between the Reader and the Reeler.

3.4 FIELD INSTALLABLE OPTION

The Reeler can be incorporated in any Control which employs a 44D232560-G01 Reader by following the instructions contained in the Installation Drawing of Figure 3.1. However, this diagram does not indicate the preferred method of wiring to be used in the interfacing. Detailed information regarding the field installable Reeler option for any particular Control can be obtained by contacting the local General Electric I & SE representative.

INSTALLATIØN DIAGRAM 3N3200TRI04AI TAPE REELER

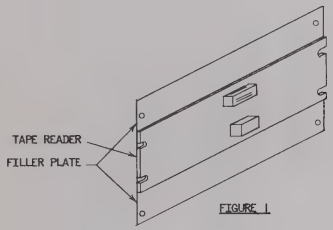


FIGURE 1

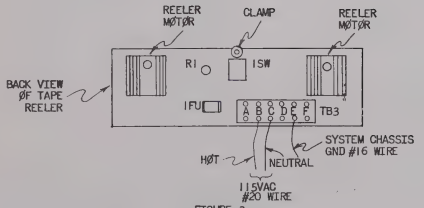


FIGURE 3

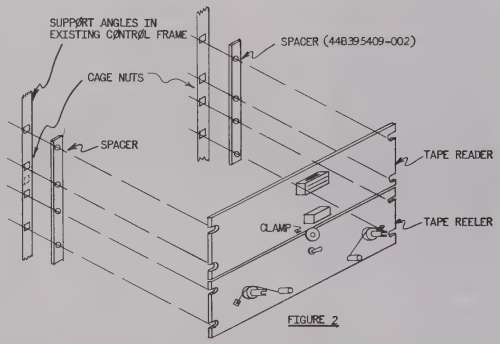


FIGURE 2

3N3200TRI04AI TAPE REELER

INSTALLATIØN INSTRUCTIØNS:

* 1. REMØVE CABLE FRØM REAR ØF TAPE READER.

* 2. REMØVE TAPE READER AND FILLER PLATE (FIG. 1) SEE NØTE 2

* 3. IN ALL 7500 SERIES CØNTRØLS, MØDIFY THE TRD2A P.C. BØARD (44A392618-G02) BY CØNNECTING A .0047 MFD. CAPACITØR (9338597F47) ACRØSS C14 AS SHØWN IN FIGURE 4. IF A TRD2B P.C. BØARD (44A392618-G02) IS USED NØ MØDIFICATIØN IS NECESSARY.

* 4. IN 7520 AND 7530 SERIES CØNTRØLS, A CØNTRØL MØDIFICATIØN INCLUDING P.C. BØARD DTRI AND THREE PUSHBUTTØNS ARE REQUIRED TØ IMPLEMENT THE REWEND FUNCTIØN FØR THIS REELER ØPTIØN. CØNTACT THE LØCAL GENERAL ELECTRIC REPRESENTATIVE FØR DETAILS.

5. MØUNT TAPE READER TØ SUPPØRT ANGLE WITH SPACERS AS SHØWN (FIG. 2) MØUNT TAPE REELER UNDER TAPE READER AS SHØWN (FIG. 2) CLAMP THE READER AND REELER PANELS TØGETHER USING THE ØVERSIZE WASHER CLAMP SUPPLIED WITH THE REELER (FIG. 2).

6. CØNNECT CABLE TØ TAPE READER.

7. CØNNECT 115VAC TØ TB3-B&C AS SHØWN (FIG. 3)

8. CØNNECT SYSTEM CHASSIS GND TØ TB3-E AS SHØWN (FIG. 3).

NØTES:

1. *INSTRUCTIØN FØR RETRØFIT CØNTRØLS.

2. FILLER PLATE IS NØT USED WITH THIS REELER.

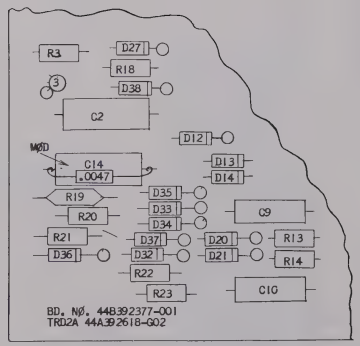


FIGURE 4
TRD2A CØMPØNENT LAYØUT SHØWING CAPACITØR MØD.

Figure 3.1
INSTALLATION DIAGRAM

SECTION 4
THEORY OF OPERATION

4.1 GENERAL OPERATION

The 150-CPS Tape Reeler is used in conjunction with the 44D232560-G01 150-CPS Tape Reader. The Reeler has a 5 1/4 inch by 19-inch base and is mounted directly below the Reader. The only power required for operation is 115 VAC 50 to 60 Hertz. For normal operation, a tape is threaded through the Reader read head and under the Reeler arm rollers as shown in Figure 1.2. When the Reader reads forward (left to right), tape is pulled off the left reel and is taken up by the right reel. In rewind, the opposite action occurs. The Reeler is supplied with 5 1/4-inch reels capable of holding up to 375 feet of tape. It is to be noted that there are no printed-circuit boards in the Reeler and there are no electrical connections between the Reader and the Reeler.

The running speed of the Reeler is controlled by the Reader which is driven by any of 4 printed-circuit boards: TRD2A, TRD2B, TRAD1, or TRAD2. The forward speed is approximately 150-CPS. The rewind speed should be approximately 235-CPS as provided in the TRD2B, TRAD1, and TRAD2 printed-circuit boards. The TRD2A printed circuit board has to be modified to reduce the rewind rate to avoid step motor chatter when it first starts into rewind. The modification to the TRD2A printed-circuit board consists of connecting a .0047 MFD capacitor (933B597-F47) in parallel with C14 on the printed-circuit board as discussed on the Installation Diagram of Figure 3.1. This will reduce the rewind rate to the proper level.

The Reeler has a three-position toggle switch and its functions are as follows. The switch center position, designated LOAD/OFF, de-energizes both reel motors for loading tape or running the Reader in the Loop mode. With the switch in the center position, the arms go to the down position engaging the reel motor brakes, thus preventing the tape from running off the reels uncontrolled. The switch upper position, designated RUN, energizes both reel motors with equal torque (2.3 oz-in) but of opposite rotation, the left reel pulling tape to the left and the right reel pulling tape to the right. The arms are lifted off the brakes and the rollers come to rest a little below the center of the base plate. In this position the Reeler will follow the Reader in both Forward and Rewind. The switch lower position, designated MANUAL REWIND, energizes both motors as in run except the right reel motor torque is much reduced. After reading a tape, MANUAL REWIND can be used to rapidly rewind the tape from the right reel to the left reel by disengaging the tape from the readhead (sprocket wheel) and letting it run on the arm rollers. To prevent the right arm from engaging its brake during MANUAL REWIND, the mechanical toggle should be placed in the MANUAL REWIND position. After MANUAL REWIND is completed, the mechanical toggle should be returned to the RUN position.

4.2 REEL MOTOR DRIVE SYSTEM

The reel drive system is composed of 2 shaded pole AC motors driven in torque opposition and 2 tension arms which are spring restrained. In normal RUN operation, the left motor is continuously torqued counterclockwise and the right reel motor is continuously torqued clockwise. With tape threaded through the Reader read head and under the arm rollers, and the Reader at standstill, the arms are raised to the STANDBY position which is approximately 3 inches below the top edge of the Reeler panel and is defined by the panel silk screen pattern. Each arm is restrained by a two-spring system with a weak gradient below the STANDBY position and a stiff gradient above the STANDBY position. The motor torques cause the arms to raise to the gradient transition position of STANDBY. When the Reader is caused to read forward (left to right) the Reeler follows automatically. The force on the tape due to the stepmotor drive causes the left arm to raise above the STANDBY position and imparts a force to the left reel which overcomes the left reel motor torque and pulls tape from the left reel. The forces involved are small and do not deteriorate the sprocket holes of paper tape resulting in long paper tape life. As the tape is read, the right arm goes lower than the STANDBY position and the right reel motor turns taking up the tape tending to raise the right arm back to the STANDBY position. During cycle reading of the tape, both arms are in oscillatory motion about their STANDBY positions because of the momentum of the reels which is a function of the reel inertia which is dependent upon the amount of tape on the reel. For a steady reading rate, the arms stabilize near the STANDBY position and the reels turn at a steady rate. When the Reader goes into rewind, the Reeler automatically follows the Reader and the Reeler operation is identical to that in the forward direction except tape is pulled from the right reel and wound up on the left reel.

4.3 REEL SIZE

The Reeler is fully capable of satisfactory operation when using the supplied 5 1/4-inch reels which can hold up to 375 feet of tape. Should a greater tape capacity be required, then a larger size reel may be employed. The Reeler is capable of driving a 6-inch

reel which can hold up to 500 feet of tape with satisfactory operation. However, the increase in inertia causes the Reeler operation to appear somewhat sluggish, especially when cycling. In 1050 Controls where lengthy "system software" tapes are sometimes necessary, 7 1/2-inch reels capable of holding up to 800 feet of tape may be used. This size reel should only be used when driving the tape at a constant rate--not for cycle operation because of the sluggish Reeler response due to the greatly increased inertia, especially with a full reel of tape. With 7 1/2-inch reels mounted on the Reeler, the reel flanges extend beyond the side edges of the panel approximately 3/8 inch. In Controls other than the 1050, there may be an interference between the reel flange and the sheet metal surrounding the Reeler mounting area which may preclude using a 7 1/2-inch reel in these Controls. However, if necessary, the 7 1/2-inch reel flange could be turned down to be made serviceable.

4.4 MANUAL REWIND OPERATION

In normal operation, it is expected that rewind should be accomplished by automatically rewinding with the Tape Reader. However, in those cases where the length of tape is considerable, the MANUAL REWIND function provides a fast rewind capability and can be a timesaving feature. This would be especially true for rewinding lengthy "system software" tapes used in the 1050 Controls.

The recommended procedure for MANUAL REWIND when rewinding long executive tapes is as follows:

1. Turn the Reeler switch to the OFF position.

2. Wrap 3 to 4 turns of tape on the left reel and pull tight to set the fingers out and to prevent the tape from slipping on the reel core.

3. Put the tape under the left reel tension arm.

4. Turn the lever under the right tension arm to the REWIND position to release the brake on the right reel.

5. Turn the reel switch to the RUN position.

6. When about two-thirds of the tape is rewound onto the left reel, move the switch to the MANUAL REWIND POSITION to finish the rewind operation.

7. Move the switch to OFF to remove the tape reels.

8. Return the lever under the right tension arm back to the RUN position.

NOTE

When the Reel switch is in the MANUAL REWIND position, torque is reduced on the right reeler motor permitting the left reel with tape at a large radius to pull tape from the nearly empty right reel withs its smaller radius.

SECTION 5
OPERATION

5.1 REELER OPERATOR'S DEVICES

The operator's devices on the Reeler are shown in Figure 5.1 and are listed below.

1. Reeler Function Switch - A three-position toggle switch to provide the following functions:

A. RUN position (switch upper position) - Powers each reel motor with equal torque but of opposite direction (left motor counterclockwise; right motor clockwise). Used in normal Tape Reader operation.

B. LOAD/OFF position (switch center position) - Removes power from both reel motors. Used when loading tape or when running Reader in the Loop mode.

C. MANUAL REWIND position (switch lower position) - Powers the left reel motor with full counterclockwise torque and the right reel motor with reduced clockwise torque. Used when manually rewinding tape.

2. Reeler Mechanical Toggle - A two-position mechanical toggle for controlling the right reel braking as follows:

A. RUN position - Allows right tension arm to drop down sufficiently to engage right reel brake. This position is for normal Tape Reader operation.

B. MANUAL REWIND position - Prevents right tension arm from dropping down sufficiently to engage right reel brake. This position is used in MANUAL REWIND only.

3. Reels - The reels are removable and the self-locking hubs accept reels with standard 1/2-inch I.D. hubs.

5.2 READER LOOP OPERATION

When the Reader is to be used in loop operation, put the Reeler switch in the LOAD/OFF position and let the tension arms go to their downmost position.

5.3 TAPE LOADING

The tape should have leaders 5 foot in length at each end of the program tape and the tape should be loaded on the left reel. Place the Reeler switch in the LOAD/OFF position to de-energize the reel motors. Lift

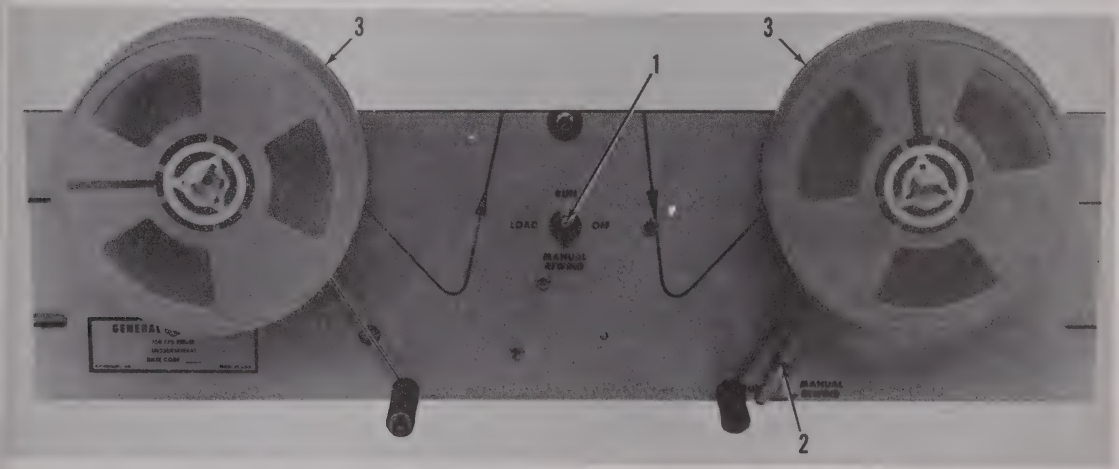


Figure 5.1
REELER OPERATOR DEVICES

the left arm to release the left reel motor brake and pull off enough leader to loop below the rollers and affix it in the slot of the right reel. Wrap 6 or 7 turns of tape on the right reel. Next, lift the tape between the 2 rollers up to the Reader and properly load it in the read head. Put the Reeler switch in the RUN position for normal operation.

5.4 MANUAL REWIND OPERATION

Once the tape has been read and it is not desired to rewind it using the Tape Reader because of the time involved, the MANUAL REWIND function can be used. Stop the Reader and put the Reeler switch in LOAD/OFF. Lift the tape from the read head and take up the slack by rotating one of the reels keeping the tape under the rollers. Put the Reeler mechanical toggle in the MANUAL REWIND position to disengage the right reel brake. Use one of the following 2 procedures.

Procedure 1 - If there is more tape on the left reel (or approximately equal on both reels), put the Reeler switch in the MANUAL REWIND position and rewind the tape to the left reel. When rewind is complete, put the Reeler switch in the LOAD/OFF position and put the mechanical toggle back in the RUN position.

Procedure 2 - If there is significantly more tape on the right reel than on the left reel, put the Reeler switch in the RUN position to start rewind. Allow the Reeler to rewind until there is more tape on the left reel than on the right reel; then quickly throw the Reeler switch to the MANUAL REWIND position and complete the rewind. When rewind is complete, put the Reeler switch in the LOAD/OFF position and put the mechanical toggle back in the RUN position.

Do not allow the reel motors to run free for any length of time when the brakes are engaged since this causes a deterioration of the hub brake surface.

SECTION 6
CHECKS AND ADJUSTMENTS

6.0 GENERAL

This section presents the checks and adjustments procedures required to obtain optimum performance from the equipment.

WARNING

DANGEROUS VOLTAGES EXIST IN THIS EQUIPMENT. EXERCISE CAUTION WHEN PERFORMING ANY OF THE FOLLOWING CHECKS OR ADJUSTMENTS.

6.1 TENSION ARM STANDBY POSITION CHECK

With tape threaded through the Reader read head and under the arm rollers, the Reader at standstill, and the Reeler switch in the RUN position, in a properly adjusted Reeler the arms will be raised to a position approximately 3 inches below the Reeler panel top edge. This position is defined as the STANDBY position and is indicated by the panel silk screen pattern. Significant deviation from the STANDBY position would require a check of the tension arm adjustment of the associated arm springs and/or the associated reel motor torque.

6.2 TENSION ARM ADJUSTMENT

The tension arm is restrained by a two-spring system with a spring gradient change occurring in a properly adjusted arm at the STANDBY position. The springs act on the arm shaft which extends through the panel. The weak spring is always acting on the shaft lever pin, but the stiff spring engages the shaft lever pin when the arm is raised to the STANDBY position. To adjust the arm properly, loosen the set screw which holds the arm to the arm shaft while applying pressure to the back of the arm shaft since it is under spring compression. Rotate the arm to the STANDBY position as defined by the panel silk screen pattern. While holding the arm in this position, rotate the shaft until the pin on the shaft lever just touches the stiff spring. Push the shaft forward compressing the compression spring so that there is .02 to .04 inches of shaft end play. Do not compress the compression spring completely. Tighten the set screw. Check the adjustment by properly threading tape between the Reader and the Reeler and applying power as described in paragraph 6.1.

6.3 SPRING CHECKS

Improper restraining of the tension arm may be due simply to the fact that the arm springs are not being properly engaged on the pin of the shaft lever. Check that the springs are properly engaged.

6.4 MOTOR CHECKS

With the reels removed, the arms lifted off the brakes, and the Reeler switch in the LOAD/OFF position, check that the motors spin freely by hand. If they do not spin freely, a motor problem is indicated. Put the Reeler switch in the RUN position and check that the left reel motor rotates rapidly counterclockwise, and the right reel motor rotates rapidly clockwise. If either motor does not appear to be powered, check the electrical connection. If either motor rotates in the wrong direction, the motor is reverse-mounted. To check the motor torque, put the Reeler switch in the LOAD/OFF position and cause both motor brakes to be disengaged. Then wrap a cord around the reel hub shaft and tie it to a force indicator rated up to 10 ounces. Put the Reeler switch in the RUN position and the force indicator should indicate between 7.5 and 9.5 ounces. A hot motor indicates greater force than a cold motor. A low force (torque) indication would indicate a motor problem or possibly a motor mounting problem. Check for binding or bad bearing.

6.5 ROLLER CHECKS

Check that the rollers spin freely. Also check that the rollers are essentially perpendicular to the panel so that the tape does not run off the edge of the roller. The arms may have become bent during handling or shipping.

With the arms in the downmost position, the rollers should be above the lower edge of the panel. In some Controls if the rollers are below the bottom edge of the panel, an interference between the roller and the tumble box top edge may cause the reel brakes not to engage. To compensate for this condition, loosen the four reel motor mounting screws and shift the motor position to lift the arms up to the proper position. Then tighten the screws. Check that motor operation is still proper per paragraph 6.4.

SECTION 7
PREVENTIVE MAINTENANCE

7.1 MAINTENANCE SCHEDULE

Table 7.1 has been prepared to provide guidance in obtaining optimum performance of the 150-CPS Reeler.

Table 7.1
MAINTENANCE SCHEDULE

ITEM	ACTION	TIMING
Bearings Motors Rollers Arm Shaft	No lubrication required for the life of the items.	
Reel Shaft "O" Ring	Check for wear causing reel to be loose on shaft, see paragraph 9.5 for replacement.	1,000 hours or as required.

7.2 TOOLS AND TEST EQUIPMENT

Table 7.2 lists the tools required to perform routine maintenance and adjustment.

Table 7.2

ITEM	USE	TYPE
Force Indicator	Arm Adjustment	0-10 ounces
Allen Wrenches	Arm Adjustment	Standard
Snap-Ring Pliers	Rollers, Shafts	Standard
Screwdriver	General	Standard
Voltmeter	General	120 volt AC

SECTION 8
TROUBLESHOOTING

8.0 TROUBLESHOOTING GUIDES

Table 8.1 contains troubleshooting information for use by maintenance personnel as an aid in the maintenance of the 150-CPS Reeler.

WARNING

DANGEROUS VOLTAGES EXIST IN THIS EQUIPMENT. EXERCISE CAUTION WHEN TROUBLESHOOTING THIS EQUIPMENT.

Table 8.1
TROUBLESHOOTING GUIDE

SYMPTOM	CAUSE	CORRECTIVE ACTION
No motor power	Blown fuse	Check for line or component short.
Motor does not run	Open motor winding	Replace motor per paragraph 9.2.
	Bad switch contact	Replace switch per paragraph 9.12.
	Open wire	Repair wire.
Right motor does not run in manual rewind	Open resistor R1	Replace resistor R1 per paragraph 9.12.
Arm not properly spring restrained	Spring not engaging pin on shaft lever	Check springs and shaft lever. Replace spring if broken per paragraph 9.10. Replace shaft if pin is broken per paragraph 9.8.
Arm out of adjustment	Loose arm set screw	Adjust arm per paragraph 6.2.
Brakes do not properly engage	Roller interference	Adjust motor position per paragraph 6.5.
Reels loose on hub	Worn "O" ring	Replace "O" ring per paragraph 9.5.
	Broken hub	Replace hub per paragraph 9.3.

SECTION 9
PARTS REMOVAL AND REPLACEMENT

9.1 GENERAL

All parts are kept in stock and can be shipped within 24 hours from receipt of order. When the application is critical or where down time is a serious factor, consider using a spare Reeler.

If the Reeler is removed from the Control for repair, upon reinstalling check that the tension arm restraining springs on the back of the unit are resting properly on their respective pins. See Figure 10.2.

9.2 MOTOR ASSEMBLY REPLACEMENT (2, 3, Figure 10.1)

1. Disconnect the motor leads from TB3.

2. Note how the springs are restrained against the motor housing.

3. Remove the 2 upper motor mounting screws, and hold the heat sink as it comes off.

4. Remove the 2 lower motor mounting screws, and hold the motor as it comes off.

5. Place the new motor in position with the springs properly restrained.

6. Insert the 2 lower motor mounting screws and snug tighten them.

7. Hold the heat sink in position, insert the 2 upper motor mounting screws, and snug tighten them.

8. Check that the brake properly engages and the rollers are above the panel lower edge per paragraph 6.5. Shift the motor housing until these conditions are met, if necessary. Tighten the 4 motor mounting screws.

9. Lift the arm to release the brake and see that the motor spins freely by hand per paragraph 6.4.

10. Check that the arm is in proper adjustment per paragraph 6.2. Readjust it if necessary.

11. Connect the motor leads to TB3. Lift the arms to release the brakes, apply power and see that the motor runs properly.

9.3 REEL HUB REPLACEMENT (2, 3, Figure 10.1)

1. To replace the reel hub, it probably will be necessary to remove the motor from the Reeler per paragraph 9.2, steps 1 through 4.

2. Drive the spring pin out which holds the reel hub and the reel hub adapter to the motor shaft.

3. Remove the reel hub.

4. Using the removed reel hub as reference, scribe the location of one pin hole in the new hub.

5. Using a 1/16-inch diameter drill bit, drill out a spring pin hole in the new hub.

6. Put the new hub on the hub adapter and line up the holes in the new hub, hub adapter, and the motor shaft.

7. Inserting the drill bit through the aligned holes, drill the second spring pin hole in the new hub.

8. Drive the spring pin into the aligned holes making sure the spring pin is flush with the surface of the new reel hub.

9. Install a reel on the hub to assure it seats properly. Remove the Reel.

10. Replace the motor in the Reeler per paragraph 9.2, steps 5 through 11.

9.4 REEL HUB ADAPTER REPLACEMENT (2, 3, Figure 10.1)

1. To replace the reel hub adapter, it will probably be necessary to remove the motor from the Reeler per paragraph 9.2, steps 1 through 4.

2. Mark the motor shaft at the back edge of the reel hub adapter. Then drive the spring pin out which holds the reel hub and the reel hub adapter to the motor shaft.

3. Remove the reel hub and reel hub adapter.

4. Put the reel hub and the new reel hub adapter on the motor shaft.

5. Position the reel hub adapter so that its back edge is aligned with the motor shaft mark made previously and hold it in this position.

6. Using a 1/16-inch drill bit, drill a spring pin hole through the reel hub, reel hub adapter, and motor shaft.

7. Drive the spring pin into the hole making sure the spring pin is flush with the surface of the reel hub.

8. Install a reel on the hub to assure that it seats properly.

9. Replace the motor in the Reeler per paragraph 9.2, steps 5 through 11.

9.5 "O" RING REPLACEMENT (2, 3, Figure 10.1)

1. Slide or roll the old "O" ring of the reel hub.

2. Roll the new "O" ring on the reel hub and push it under the hub pins.

3. Install a reel on the hub to assure that it seats properly.

9.6 TENSION ARM AND OR ARM WASHER REPLACEMENT (4, 5, 9, Figure 10.1)

1. While applying pressure to the back of the arm shaft (to prevent the compression spring from causing the arm shaft to release rapidly) loosen the arm set screw which holds the arm to the arm shaft and remove the arm and arm washer.

2. Remove the snap ring and the roller and bearings from the arm.

3. Put the roller and bearings and the snap ring on the new arm. Check that the roller rotates freely.

4. Install the new arm and/or arm washer on the arm shaft while pushing on the back of the arm shaft to compress the compression spring.

5. Adjust and check the arm following the procedures of paragraphs 6.2 and 6.5.

9.7 ARM ROLLER OR ROLLER BEARING REPLACEMENT (4, 5, Figure 10.1)

1. Remove the snap ring and the roller and bearings from the arm.

2. Put the new roller and or bearings and the snap ring on the arm.

3. Check that the roller rotates freely.

9.8 SMALL TORSION SPRING REPLACEMENT (2, 3, Figure 10.2)

1. Note how the small spring is restrained against the motor and the lever pin.

2. Remove the shaft snap ring and the small spring.

3. Install the new spring and the snap ring making sure that the spring is properly restrained.

9.9 SHAFT ASSEMBLY AND/OR COMPRESSION SPRING REPLACEMENT (1, 14, Figure 10.2)

1. Note how the small spring is restrained against the motor and the lever pin.

2. While applying pressure to the back of the arm shaft (to prevent the compression spring from causing the arm shaft to release rapidly), loosen the arm set screw which holds the arm to the arm shaft and remove the arm and arm washer.

3. Remove the shaft assembly and the compression spring from the panel sleeve bearing.

4. When replacing the shaft assembly, remove the shaft snap ring and small torsion spring and install them on the new shaft assembly.

5. Install the new shaft assembly and/or the new compression spring and push the shaft through the panel sleeve bearing, compressing the compression spring.

6. Install the arm and arm washer on the shaft.

7. Adjust and check the arm following the procedures of paragraphs 6.2 and 6.5.

9.10 PANEL SLEEVE BEARING, LARGE TORSION SPRING AND/OR SLEEVE REPLACEMENT (7, Figure 10.1, 4, 5, 6, Figure 10.2)

1. Note how the two torsion springs are restrained against the motor and the lever pins.

2. Remove the motor heat sink per paragraph 9.2, step 3.

3. Remove the shaft assembly and arm per paragraph 9.9, steps 2 and 3.

4. Using a wooden dowel or similar soft article, tap the panel sleeve bearing out from the back, catching the large torsion spring and sleeve in the process.

5. Replace the defective item and reassemble as follows. First, replace the panel bearing by tapping it into the panel from the front using a wooden dowel. Next, place the large torsion spring on the sleeve and tap the sleeve on the back edge of the panel bearing using a block to support the panel bearing so that it doesn't push out. Make sure that the sleeve and panel bearing are both fully seated and the torsion spring is in place against the motor.

6. Replace the shaft assembly, compression spring, arm, and arm washer per paragraph 9.9, steps 5 through 7.

7. Replace the motor heat sink and tighten the screws.

9.11 NOISE FILTER REPLACEMENT (12, Figure 10.2)

1. The noise filters are adhered to the panel using RTV108 adhesive to prevent vibration.

2. Using a screwdriver, break the adhesive to free the noise filter.

3. Disconnect the old noise filter and connect the new noise filter. The noise filters are non-polar and may be connected either way, but use judgement in orienting so that lug interference with other lugs on the same pin of TB3 will be avoided.

4. Adhere the new noise filter to the panel using RTV108 or equivalent.

9.12 OTHER COMPONENT REPLACEMENT

1. The remaining component replacement not covered in the preceding paragraphs are straight forward requiring no special instruction other than using accepted techniques to avoid repair errors in wiring or soldering.

SECTION 10
PARTS LIST

10.1 INTRODUCTION

This section contains the Parts List for the 150-CPS Reeler, assembly number 3N3200TR104A1.

The columns in the Parts List contain the following information:

1. Figure and Index Number - A key to locate an individual illustration and detail part on the illustration.

2. Part Number - The General Electric part number. Indented part numbers show the part number of the items contained in the preceding subassembly.

3. Description - Nomenclature of the part and modifiers necessary to identify the particular item. Indented descriptions show the items contained in the preceding subassembly.

4. Quantity - The number of parts required per assembly. For indented items in the previous columns, the quantity shows the number of parts required for the subassembly.

10.2 PROCEDURE FOR ORDERING PARTS

To order a replacement part:

1. Refer to the Parts List to determine the part number and name of the part.

2. Give full descriptive data of the item and the part number. Also give the assembly number and the GEK number on the front cover of this Instruction Book.

3. Address orders to the nearest Apparatus Sales Office or I&SE office of the General Electric Co.

FIGURE AND INDEX NO.	PART NUMBER	DESCRIPTION	QUANTITY
5 -3	44A399694-001	Reel	2
10.1 -1	44C394274-001	Base Panel	1
-2	44A397786-G01	Motor Asm. - Right Hand	1
	44A397793-001	Plastic Reel Hub	1
	44A710027-002	"O" Ring	1
-3	44A397786-G02	Motor Asm. - Left Hand	1
	44A397793-001	Reel Hub (Plastic)	1
	44A710027-002	"O" Ring	1
-4	44A397789-G01	Tension Arm Asm. - Left Hand	1
	44A399913-G01	Tension Arm - Left Hand	1
	44A394905-003	Roller	1
	44A393673-002	Ball Bearing	2
-5	44A397789-G02	Tension Arm Asm. - Right Hand	1
	44A399913-G02	Tension Arm - Right Hand	1
	44A394905-003	Roller	1
	44A393673-002	Ball Bearing	2
-6	44A399693-001	Toggle Switch	1
-7	44A393690-002	Bearing - Sleeve	2
-8	44A397788-G02	Toggle Asm.	1
-9	44A710068-002	Arm Washer	2

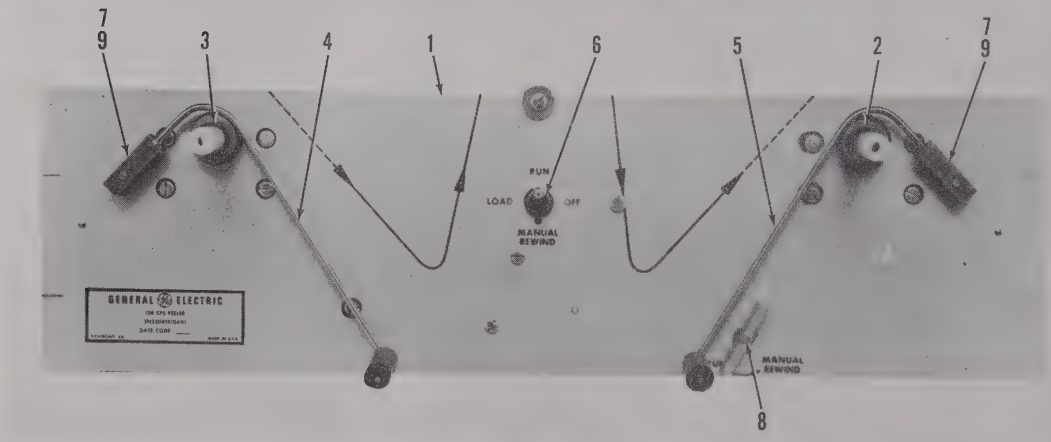


Figure 10.1
150 CPS REELER FRONT VIEW

FIGURE AND INDEX NO.	PART NUMBER	DESCRIPTION	QUANTITY
10.2 -1	44A397788-G01	Shaft Asm.	2
-2	44A399674-001	Spring, Right Hand, Rear	1
-3	44A399674-002	Spring, Left Hand, Rear	1
-4	44A399915-002	Spring, Left Hand, Front	1
-5	44A399915-001	Spring, Right Hand, Front	1
-6	44A397791-003	Sleeve	2
-7	44B211519-038	Terminal Board	1
-8	CR151X101	Jumper	1
-9	44A399626-001	Fuse Block	1
-10	K9774740P5	Fuse, 2 Amp	1
-11	44A397790-001	Heat Sink	2
-12	44B233199-001	Noise Filter, RC Network	2
-13	K8622212E15	Resistor, 150-ohm, 10-watt	1
-14	44A213777-002	Compression Spring	2

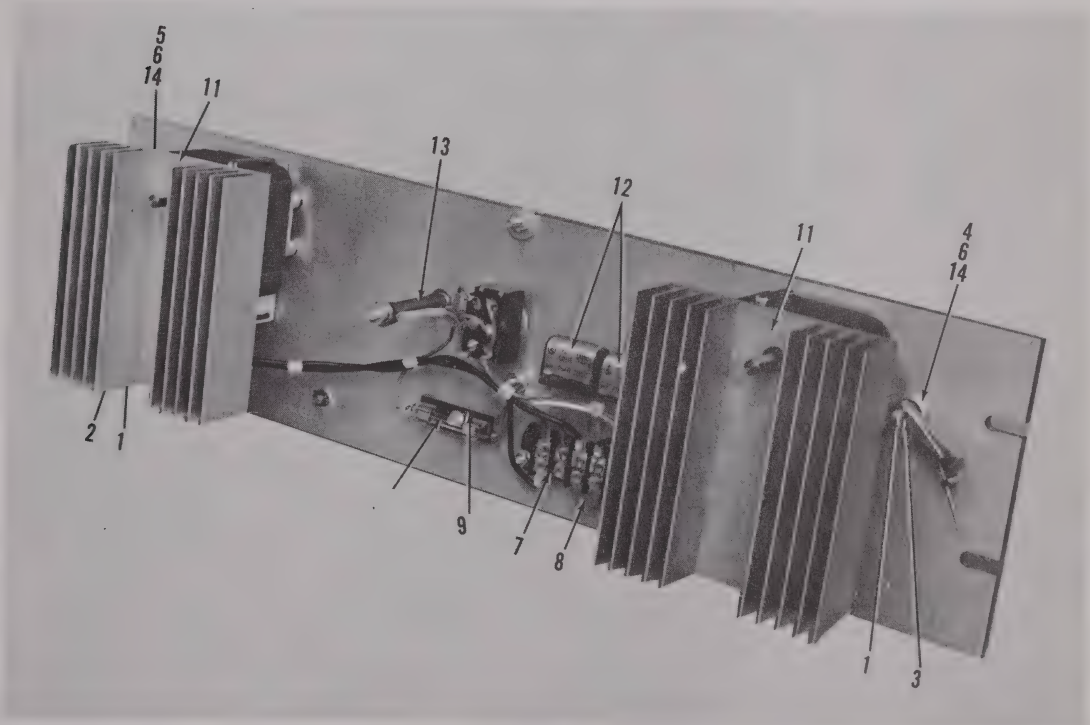


Figure 10.2
150 CPS REELER REAR VIEW

SECTION 11
DRAWINGS

CONTENTS

This section contains the following drawing:

44C285383 - 150-CPS Reeler Elementary

NOTES: A. WITH POWER ON AND LOOKING AT FRONT OF PANEL

1) LEFT REEL MOTOR ROTATES CCW, RIGHT REEL MOTOR ROTATES CW
2) WITH 1SW IN RUN POSITION, BOTH MOTORS HAVE EQUAL TORQUE (APPROX. 2.3 OZ-IN)
3) WITH 1SW IN MANUAL REWIND POSITION, THE RIGHT REEL MOTOR HAS MUCH REDUCED TORQUE

B. LF AND RF ARE MOTOR ELECTRICAL NOISE SUPPRESION NETWORKS (NON POLAR)

150-CPS REELER ELEMENTARY

Ref. 44C285383

CHAPTER XII
POSITION FEEDBACK SYSTEMS

RESOLVER FEEDBACK UNITS FOR 550 AND 1050 CONTROLS

The Resolver Feedback (pickup) units used with the Mark Century 550 and 1050 Controls are designed to be coupled directly to the machine leadscrew. They are normally shipped with the Mark Century Control, but may sometimes be packed separately in especially designed shipping containers.

Upon receiving the Resolver Feedback units, inspect them for shipping damage. If damage is apparent, promptly file a claim with the transportation agency, and notify the General Electric Company.

If the units are not installed immediately, repack them in the original container, being sure to use the anti-rust wrappings. Store them in a clean, dry place where there is no construction work in progress and where the ambient temperature does not exceed -40°C and 85°C.

DESCRIPTION

The Resolver Feedback Unit is a high-precision device which senses the position of the machine. The identification numbers of the Resolver Feedback units for Contouring controls are in the 3N1000FB103 series. In order to ascertain the Pickup unit which is suitable for your particular Control, as determined by various types of scales and lead screws, refer to the tables on pages 2 and 3.

The pickup units have aluminum covers with gaskets to keep out foreign matter. They are provided with rabbets which are concentric with the input shaft, and a clamping flange for mounting purposes. Pinned to the input shaft is a flexible coupling to be attached to the machine lead-screw.

The pickup housings are not designed to support any additional weight or force.

INSTALLATION

Since the precision with which the pickup unit is coupled to the machine motion directly affects the accuracy of the machine positioning, it is important to:

1. Couple the pickup units directly and stiffly to the lead screw.

2. Make sure that the bores in which the rabbets are situated provide a close fit and are concentric with the shaft extension of the lead screw.

3. Make sure that the maximum misalignment between the shaft of the pickup unit and the lead screw does not exceed 0.005 inch T.I.R.

Through a precision gear-train, the Resolver Feedback unit transmits the angular position of the machine lead-screw to a synchro resolver.

The scale of the pickup unit is the amount of machine motion that produces one revolution of the synchro resolver. The chart on pages 2 and 3 shows which pickup units may be applied to the various 550 Controls.

The internal gear-ratio of the pickup unit is established by:

1. The pitch of the lead screw and

2. The required scale (machine travel/revolution)

This gearing is generally stated as the ratio between one revolution of the input shaft and the corresponding number of revolutions of the synchro resolver of the pickup unit. A 1:2 ratio means that one revolution of the input shaft (which is directly coupled to the lead screw) produces two revolutions of the synchro resolver.

Figure 1 shows an outline drawing of a series 103 pickup unit with a single-mesh gear-train. A photograph of this unit with the cover removed is shown in Figure 3. Figure 2 shows an outline drawing of a series 101 pickup unit with a double-mesh gear-train.

The electrical connection diagram for the series 103 unit is shown in Figure 4; the one for the series 101 unit is shown in Figure 5.

SYNCHRO RESOLVER

The synchro resolver is mounted on an eccentric which is used for adjusting the center distance between two gears in order to remove backlash.

Ten or Fewer Revolutions

When ten or fewer revolutions of the synchro resolver are required for one revolution of the input shaft, the internal gear-train consists of only one mesh. One gear is on the input shaft of the pickup unit; the other gear is attached to the shaft of the synchro resolver.

More Than Ten Revolutions

When more than ten revolutions of the synchro resolver are required for one revolution of the input shaft, a double-mesh internal gear-train is required. (See Figure 2.) Just as in the single-mesh unit, there is a gear on the input shaft of the pickup unit and another attached to the shaft of the synchro re-

solver. In addition, a torque motor is included in the double mesh pickup unit to remove the backlash from the second mesh. The torque motor requires a 0.82 MFO capacitor which is also included within the pickup unit.

The synchro resolver has two excitation windings. A voltage of 2500 Hz is applied to each of these windings. Although the voltages are equal in magnitude, their phases are 90° apart.

The output of the synchro resolver is a voltage of 2500 Hz. This voltage has a constant amplitude, but its phase is proportional to the angular position of the resolver shaft. Any angular rotation of the resolver shaft produces an electrical phase shift that is equal to the shaft displacement. The Control compares the phase of the resolver output with a Command Phase signal to determine the error in machine position.

PICKUP SCALING FOR 550 CONTROLS

The pickup-unit scaling which may be used with the various 550 Controls is:

Control Type	Scaling
550M	0.2"/Rev
550MPM	0.1"/Rev; 2mm/Rev
550MC	0.1"/Rev; 2mm/Rev
550L	0.2"/Rev
550LM	5mm/Rev
550T	0.1"/Rev; 2mm/Rev; 5mm/Rev
550TX	0.1"/Rev; 2mm/Rev
550MBD	2mm/Rev.

STANDARD 3N1000FB103 PICKUP UNITS (See Figure 1.)

MODEL NUMBER	SHAFT/RESOLVER GEAR-RATIO	SCALE UNITS	PITCH OR LEAD OF LEAD SCREW
3N1000FB103A2	1:5	0.1"	2 Pitch
		0.2"	1 Pitch
3N1000FB103B2	1:2.5	0.1"	4 Pitch
3N100FB103B4	1:125	0.2"	4 Pitch
3N100FB103C2	1:2	0.1"	5 Pitch
3N100FB103C4	127:125	0.2"	5 mm Lead
3N1000FB103D2	1:3 1/3	0.1"	3 Pitch
3N1000FB103E2	1:1	0.1"	10 Pitch
		0.2"	5 Pitch
		5 mm	5 mm Lead
3N1000FB103F2	1:10	0.1"	1 Pitch
		5 mm	50 mm Lead
3N1000FB103A2	1:5	2 mm	10 mm Lead
3N1000FB103B2	1:2.5	2 mm	5 mm Lead
3N1000FB103C2	1:2	2 mm	4 mm Lead
3N1000FB103F2	1:10	2 mm	20 mm Lead

(continued)

STANDARD 3N1000FB103 PICKUP UNITS (See Figure 1.)

MODEL NUMBER	SHAFT/RESOLVER GEAR-RATIO	SCALE UNITS	PITCH OR LEAD OF LEAD SCREW
3N1000FB103G2	1:4	2 mm	8 mm Lead
3N1000FB103H2	20:127	2 mm	2 Pitch
3N1000FB103J2	25:127	2 mm	2.5 Pitch
3N1000FB103N2	50:127	2 mm	5 Pitch
3N1000FB103R2	1:8	5 mm	40 mm Lead
3N1000FB103X2	40:127	2 mm	4 Pitch

STANDARD 3N1000FB101 PICKUP UNITS (See Figure 2).

MODEL NUMBER	INTERNAL GEAR-RATIO	SCALE UNITS	PITCH OR LEAD OF LEAD SCREW
3N1000FB101A2	1:20	0.1"	0.5 Pitch (Rack and Pinion)
3N1000FB101B2	1:20	0.1"	0.5 Pitch (Coupling)

The above tables show the most commonly used pickup unit. Information on other units is available upon request.

ADJUSTMENTS

The optimum center distance is that which gives no backlash at the point of tightest gear engagement. The center distance is adjustable between gears in the mesh that terminates at the synchro resolver. When this center distance is reduced, the backlash is reduced; when it is increased, the backlash is increased. To adjust the center distance:

1. Vary the center distance by rotating the synchro which is mounted on an eccentric. To rotate the synchro:

   a. Loosen the synchro clamps.

   b. Loosen the set of screws in the edge of the plate on which the synchro is mounted.

2. To find the optimum center distance, physically feel for backlash as the gears are rotated and adjustments are being made with the eccentric.

3. Do not make the center distances too small, or else the gears will bind and the resolver shaft will deflect slightly at each revolution due to eccentricities in the gear mesh.

NOTE: There should not be too much backlash, since it would introduce an unnecessary deadband in the measuring system. Since backlash adjustments are made at the factory, they need not normally be done in the field.

4. To zero the resolver with the machine:

   a. Keep the couplings of the pickup unit secured to the lead screw.

   b. Loosen the clamps around the clamping flange.

   c. Rotate the entire pickup unit on the mounting surface until you achieve the proper adjustment.

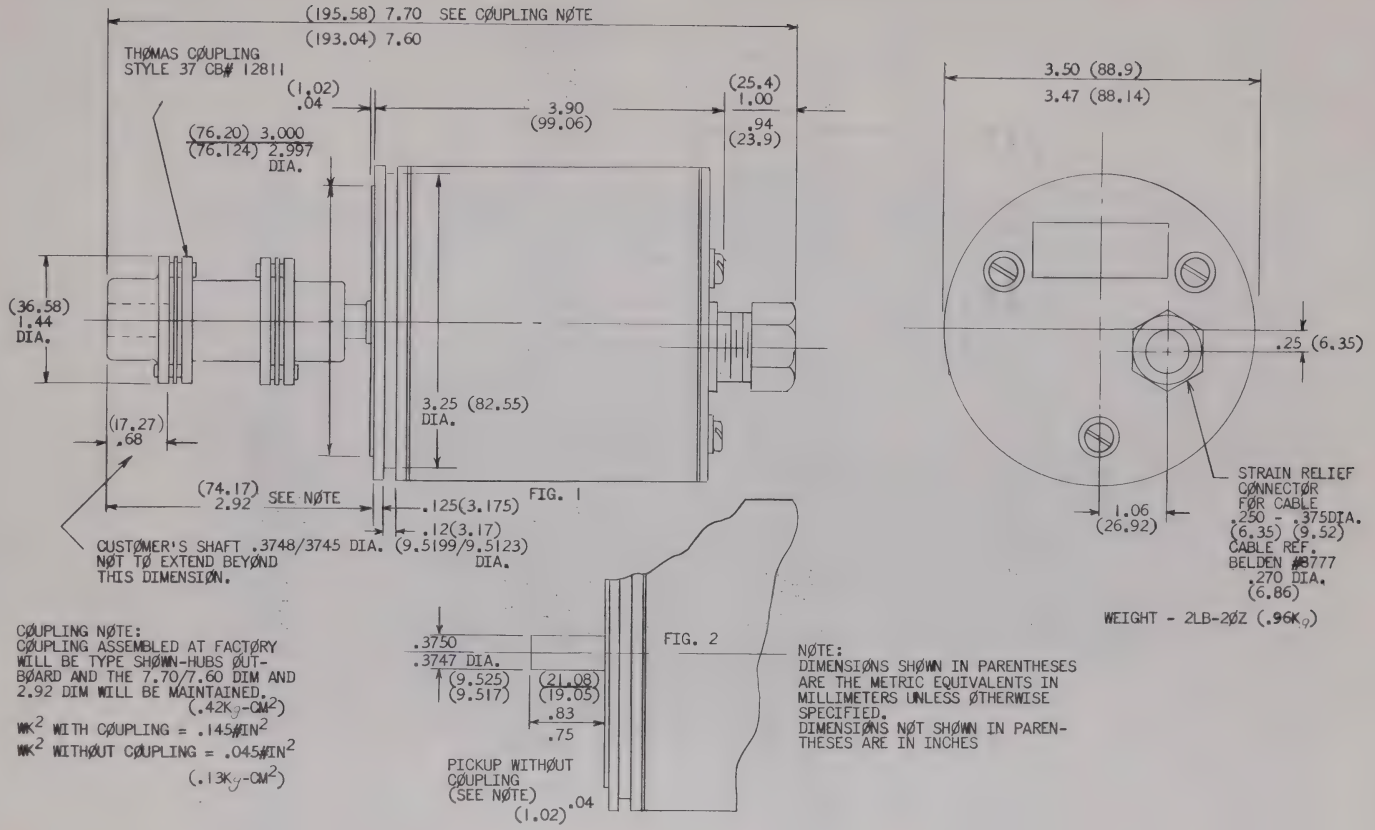
MAINTENANCE

The following chart shows the various items to be checked, the frequency at which they should be checked, and the various steps which should be followed to insure that the pickup unit is properly maintained.

ITEM	TIME FOR CHECKING	MAINTENANCE PROCEDURE
Gear Train	Once a year	Lubricate the gear train with a light application of Mor Film Cling Oil (250-300 SUS at 100°F) or its equivalent. (Mor Film Cling Oil may be obtained from L.R. Kerns Company, Chicago, Illinois).
Synchro		If it is necessary to replace the synchro: 1. Remove the synchro. To do this: a. Loosen the set screw in the side of the mounting plate. b. Remove the synchro clamps. 2. Remove the gear and eccentric from the bad synchro and attach them to the new synchro, using Loctite* Grade H. 3. Attach the new synchro to the mounting plate with the synchro clamps in place but not tight. 4. Rotate the synchro to establish the proper backlash as explained under "Adjustments". 5. Tighten the synchro clamps and set screw. 6. Recheck the backlash for proper setting. 7. Position the gear on the synchro shaft so that it lines up with the mating gear within 1/64 inch.
Torque Motor		If it is necessary to replace the torque motor: 1. Remove the gear from the motor shaft. 2. Attach this gear to the new motor, using Loctite (Grade H). 3. Align the mating gears within 1/64 inch.

CAUTION: Do not attempt disassembly of the unit other than that described above.

*Tradename of American Sealants Company, Hartford, Connecticut



Reference:
44B222434-5

TYPICAL OUTLINE OF PICKUP UNIT WITH SINGLE INTERNAL MESH (FB103 SERIES)

Figure 1

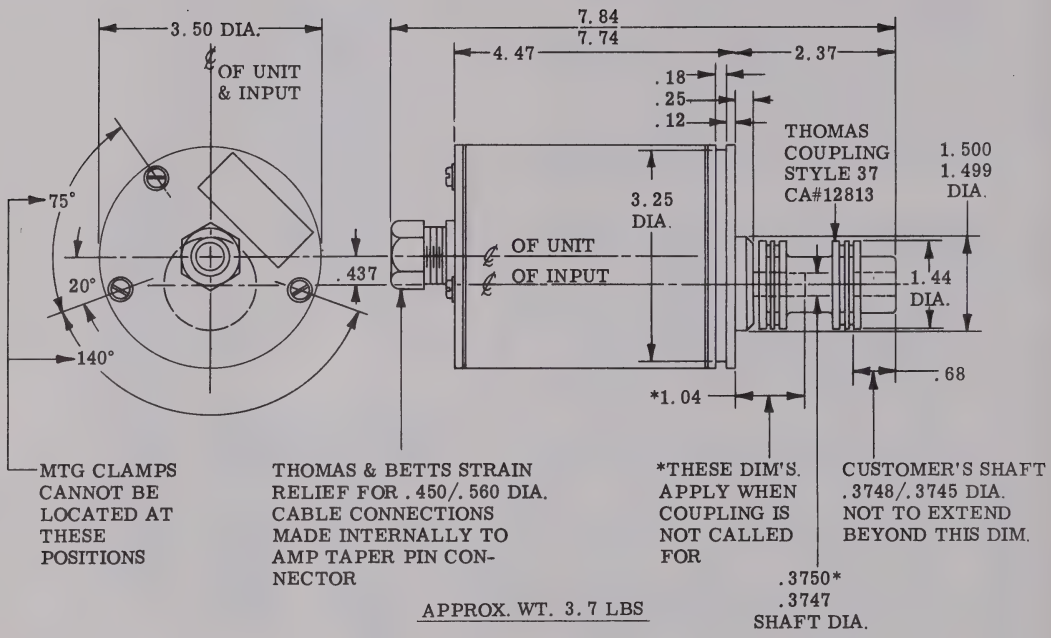


Figure 2.
TYPICAL PICKUP UNIT WITH DOUBLE INTERNAL MESH (FB101 SERIES)
(For Reference Only)

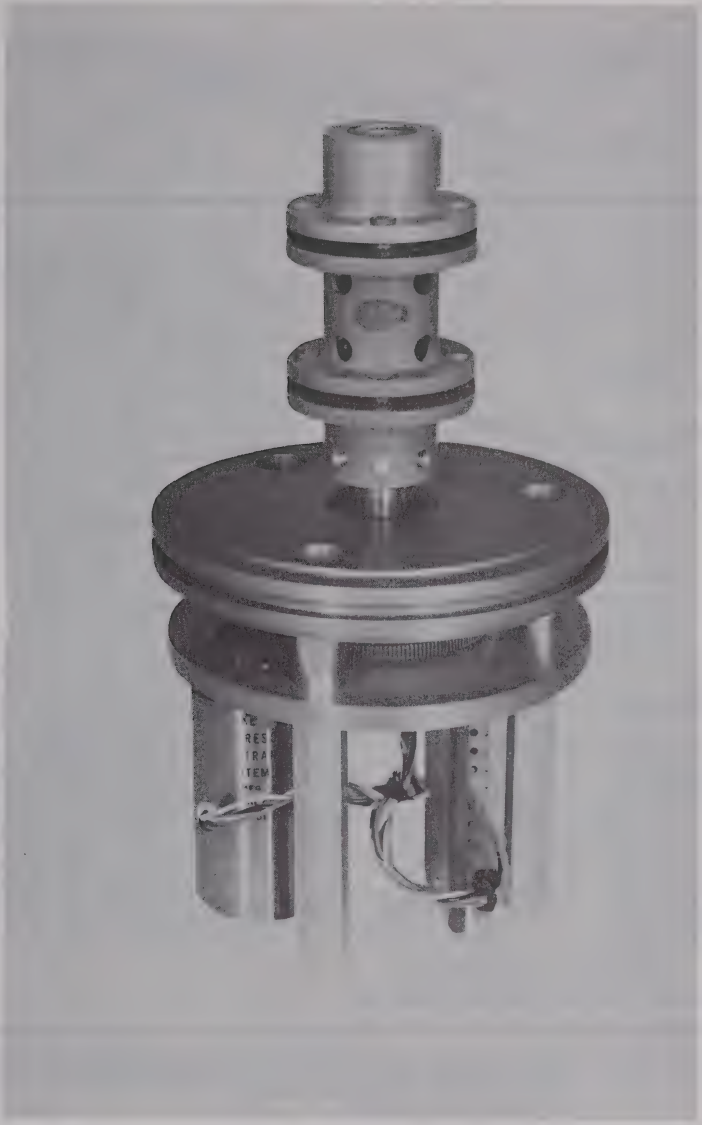
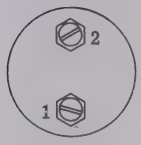
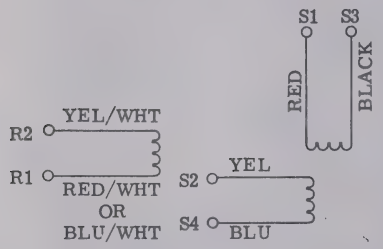


Figure 3.
TYPICAL PICKUP UNIT WITH COVER REMOVED



TACHOMETER
44B233112 - ALL PTS.

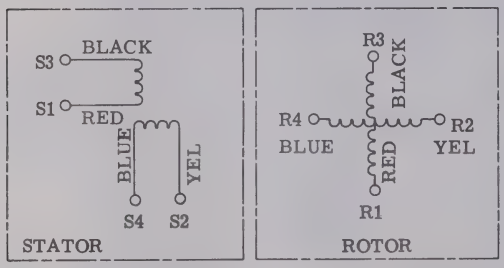
TERM. NO.	CONNECT TO
1	TB-9
2	TB-10



LEAD COLOR	CKT. NO.	CONNECT TO
YEL/WHT	R2	TB-1
RED/WHT OR BLU/WHT	R1	TB-2
RED	S1	TB-3
YELLOW	S2	TB-4
BLACK	S3	TB-5
BLUE	S4	TB-6

APPLICABLE RESOLVERS

44A393606 - ALL PTS.
44A391536 - ALL PTS.
44B233181 - ALL PTS.
44A397930 - ALL PTS.



RED SLEEVE BLACK SLEEVE

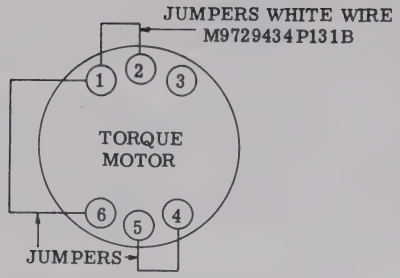
LEAD COLOR	SLEEVE COLOR	CKT. NO.	CONNECT TO
RED	BLACK	R1	TB-1
YEL	BLACK	R2	TB-2
BLK	BLACK	R3	TB-3
BLU	BLACK	R4	TB-4
RED	RED	S1	TB-5
YEL	RED	S2	TB-6
BLK	RED	S3	TB-7
BLU	RED	S4	TB-8

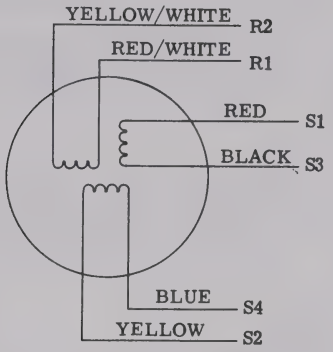
APPLICABLE RESOLVERS

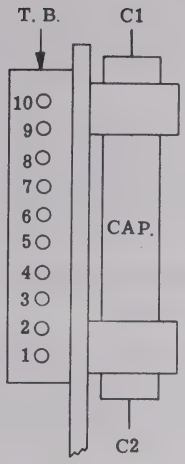
44B230648-001, 002, 005, 006, 007, 008, 009

NOTE - SEE ASSEMBLY DRAWING FOR TERMINAL BOARD ORIENTATION AND FOR FACTORY WIRING SIDE OF TERMINAL BOARD.

Figure 4.
CONNECTION DIAGRAM FOR PICKUP UNIT (SERIES FB103)
(For Reference Only)







APPLICABLE RESOLVERS

44A393606 - ALL PARTS
44A391536 - ALL PARTS
44B233181 - ALL PARTS

CAPACITOR WHITE WIRE M9729434P131B		TORQUE MOTOR WHITE WIRE M9729434P131B	
TERM. NO.	CONNECT TO	TERM. NO.	CONNECT TO
C1	TM-4	TM-1	TB-9
C2	TM-3	TM-3	TB-10

RESOLVER		
LEAD COLOR	CKT. NO.	CONNECT TO
YEL/WHT	R2	TB-1
RED/WHT	R1	TB-2
RED	S1	TB-3
YELLOW	S2	TB-4
BLACK	S3	TB-5
BLUE	S4	TB-6

Figure 5.
CONNECTION DIAGRAM FOR PICKUP UNIT (SERIES FB101)
(For Reference Only)

ELECTRONICS FOR INDUCTOSYN* SCALES

The Mark Century** Control system can be adapted for use with either the linear or the rotary Inductosyn scales manufactured by Farrand Controls, Incorporated, Valhalla, New York. The Inductosyn scales are used as the position transducer in place of the Accupin*** or Resolver feedback systems.

General Electric does not supply the Inductosyn scales and does not assume any responsibility for their performance. All accuracy statements should be obtained from Farrand Controls, Incorporated. However, General Electric does supply the necessary electronics to interface the Inductosyn scales with General Electric Numerical Controls.

DESCRIPTION

When Inductosyn scales are used, a pair of matching transformers and a preamplifier are needed to interface the scales with the Control. Refer to Figure 1 which is a connection diagram for the Inductosyn components.

One matching transformer is used for the sine and the other for the cosine channel. These transformers are used to obtain the maximum possible excitation without overloading the feedback excitation supply. An outline drawing for the transformers is shown in Figure 2.

The preamplifier amplifies the output of the Inductosyn scales or the rotor to the level that is required by the waveshaper. It also contains a filter which reduces the harmonic content of the signal and a 90-degree phase shifter, which permits an initial zero offset adjustment, and the use of a differential resolver on the output of the preamplifier.

A unique feature of the preamplifier is its capability of providing 360-degrees of zero offset for initial setup purposes without needing a differential resolver. (A differential resolver is needed if a continuously variable offset is needed during operation.) An outline drawing of the preamplifier is shown in Figure 3.

TYPES OF INDUCTOSYN SCALES

(Table 1)

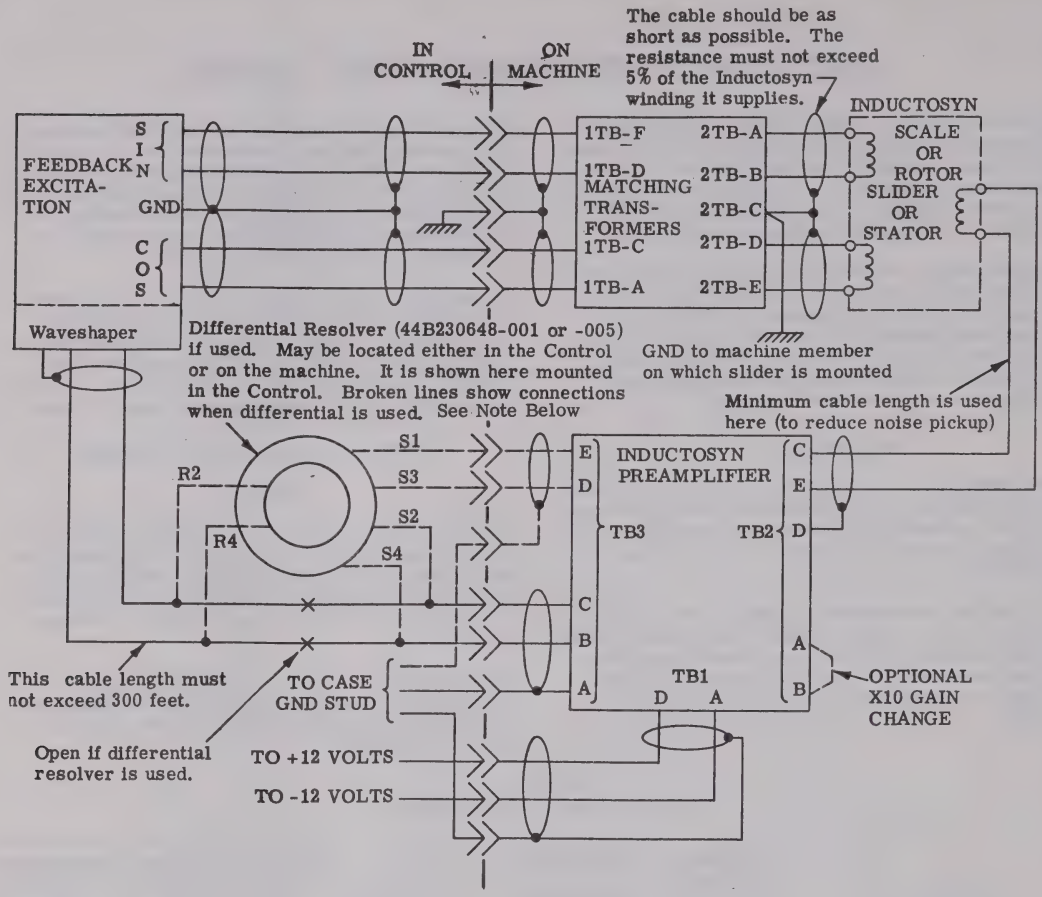
The electronics are designed to operate with the following types of Inductosyn scales. The preamplifier for all scales is catalog No. 3N7500SA101B1. The matching transformers are listed in the last column of Table 1. (All scales are of the hot-rolled steel version.)

To determine the proper matching transformers for other types of Inductosyn scales, refer to the chart on Figure 4. You will need to know the slide or stator resistance.

TABLE 1
TYPES OF INDUCTOSYN SCALES

TYPES OF INDUCTOSYN SCALES	FARRAND CATALOG NO. SCALE OR ROTOR	FARRAND CATALOG NO. SLIDER OR STATOR	BAR	AIR GAP (INCHES)	EXCITED IMPEDANCE (OHMS)	STEP-DOWN RATIO @2.5KHZ	MATCHING TRANSFORMERS 3N7500SB
Linear 0.1 inch-per cycle, wide scale	204320	204322	96	0.008	1.8	224:1	100F1
Linear 0.1-inch-per cycle, narrow-width scale	207195	207196	64	0.008	0.5	450:1	100E1
Linear 2.0 mm-per-cycle, wide scale	204540	204570	64	0.008	0.9	176:1	100F1
Rotary 12" diameter, 1-per-cycle (720-pole, built-in rotary transformer)	206736	206737		0.008	5.5	416:1	100G1
Rotary 12" diameter, 0.001 Rev.-per-cycle (2000 pole), with slip rings	206474	206473		0.008	38.0	9600:1	100H1
Rotary 12" diameter, 0.001 Rev.-per-cycle (2000 pole), with rotary transformer	207123	207124		0.005	45.0	40000:1	100H1

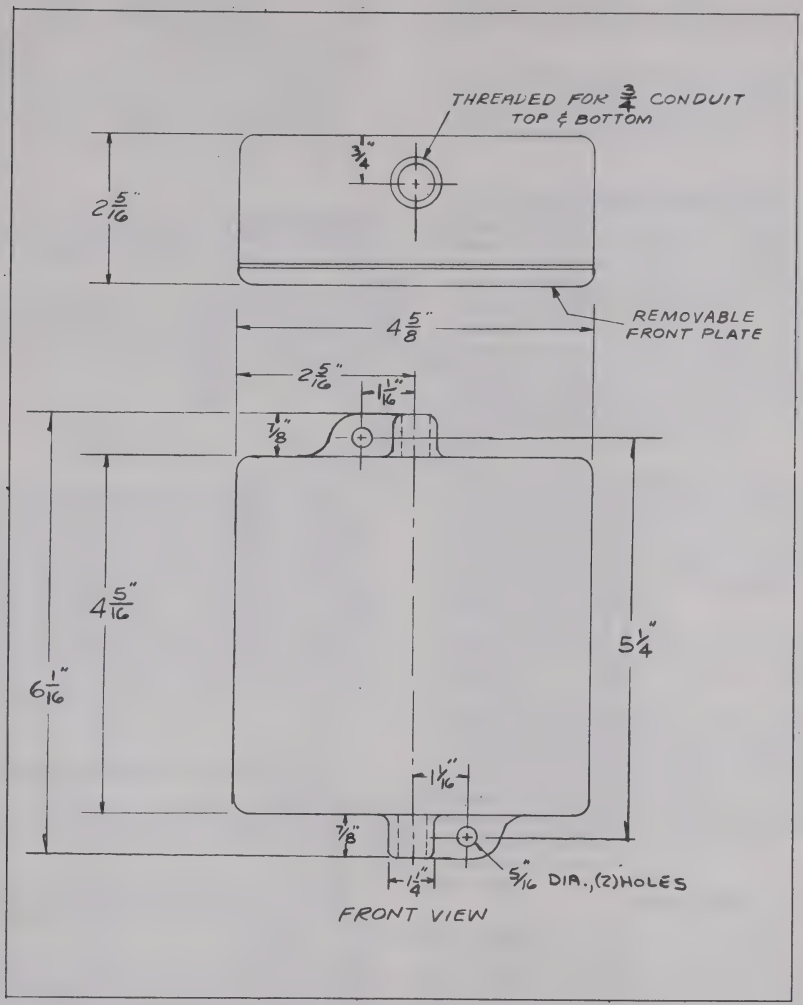
* Registered Trademark of Farrand Controls, Incorporated
** Registered Trademark of General Electric Co., USA
*** Trademark of General Electric Co., USA



Color Code for Differential Resolver

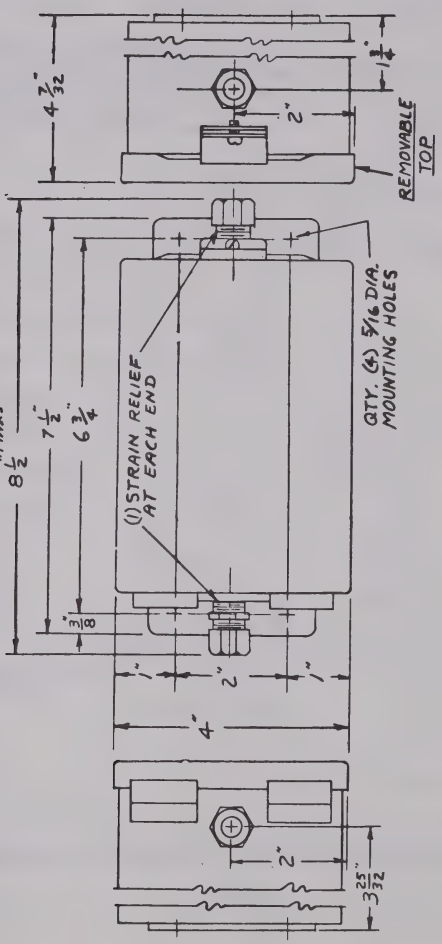
S1	-	Red	Black Sleeve
S3	-	Black	
S2	-	Yellow	
S4	-	Blue	
R1	-	Red	Not Used
R3	-	Black	
R2	-	Yellow	
R4	-	Blue	

Figure 1.
CONNECTIONS OF INDUCTOSYN COMPONENTS



OUTLINE DRAWING FOR THE MATCHING TRANSFORMERS

Figure 2



OUTLINE DRAWING FOR THE PREAMPLIFIER

Figure 3

The 2000-pole rotary Inductosyn scale with rotary transformer has a very low-signal output (about 0.2 millivolts peak-to-peak) and is also somewhat microphonic. A higher output and reduced microphonics can be obtained by using the 2000-pole rotary Inductosyn scale with slip rings. Another possibility is the use of Mercotoc* slip rings, where contact is made through mercury. For more information on the Mercotoc slip rings, contact Farrand Controls, Incorporated.

The other Inductosyn scales (Table 1) have a higher signal output, but the rotary transformer is recommended for the 720-pole Inductosyn scales.

The electronics are compatible for other types of Inductosyn scales in addition to those listed. However, before using other types, consult the General Electric Company, I. C. P. D. Engineering, Waynesboro, Virginia.

INSTALLATION

The recommended spacing between the slider and scale, the electrical parameters of input impedance, transformation ratio, and accuracy can be obtained from Farrand Controls, Incorporated. The preamplifier requires either a plus and minus 12-volt supply, or a single 24-volt supply. The current required is 9 milliamps. When a range of spacing between the slider and scale is allowable, the narrower spacing is preferred from an electrical standpoint, inasmuch as it results in a larger signal, better signal-to-noise ratio, and less error.

MATCHING TRANSFORMERS (IBT1, 2, 3 or 4)

The matching transformers and the Inductosyn preamplifiers must be mounted on the machine as outlined below.

1. Mount the matching transformers on the machine as reasonably close as possible to their loads.

Note that because the voltage of the output from these transformers is low at a relatively high current, the resistance of the wire which is used to connect them to the Inductosyn slider (linear) or stator (rotary) could cause a serious loss of signal.

2. Using No. 16 wire or larger, connect the center tap of the secondary of each transformer solidly to the machine member that carries the slider or stator. Match the wire lengths to within ±1 inch.

3. Separate the wires (which should be tightly twisted pairs) from all other Control wiring, and run them in individual conduits with no more than two pairs per conduit. If these wires are well separated from the other Control wiring, additional shielding is unnecessary.

*Trademark of Astec Technology Corporation
†Registered Trademark of Crouse-Hinds Company

The wiring from the Control to the transformers should be in twisted, shielded pairs and separated as far as possible from the rest of the Control wiring.

The matching transformers are mounted in a standard, double Conduletț box. They may be mounted in a different enclosure, provided the wiring practices outlined above are followed.

INDUCTOSYN PREAMPLIFIER (IPA1 AND IPA01)

1. Mount the preamplifier, which is housed in its shielding box, as close as possible to the Inductosyn scale or rotor. In linear systems, the preferred mounting point is near the center of the scale. Because of the low level of the input circuit to the amplifier, the circuit is susceptible to noise. This is especially true of the 2000-pole rotary Inductosyn with built-in rotary transformer because its output signal is one of the lowest (about 1/30 that of the standard inch/linear Inductosyn).

2. Since wiring between the signal source (rotor or scale) and the preamplifier is particularly critical because of the low-level signals the wiring carries, it should be a tightly twisted, shielded pair. The use of one metallic conduit (rigid or flexible) for each axis is suggested to provide magnetic as well as electrostatic shielding.

Connect the shield only at the preamplifier end of the cable (TB2-D). Do not ground the shield.

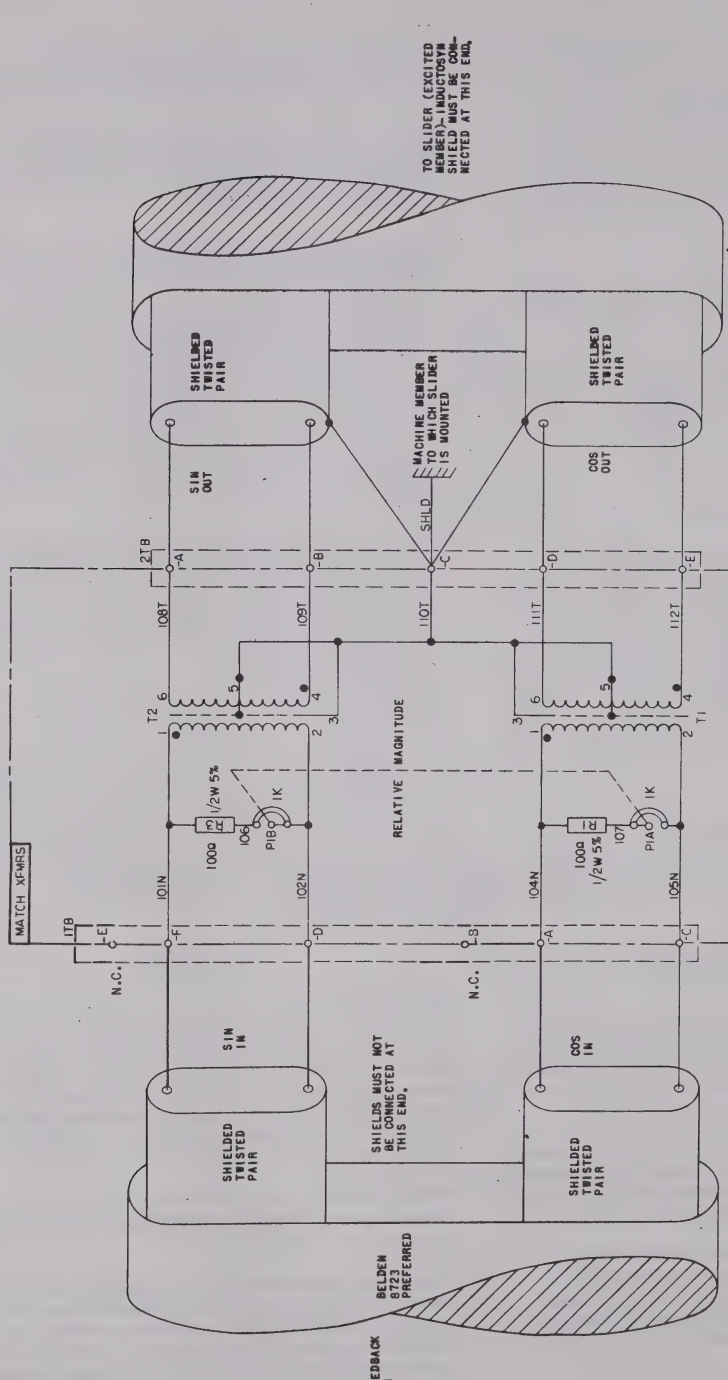
3. Connect the wiring (a twisted, shielded pair) from the preamplifier to the waveshaper in the Control. Connect the shield of this cable to the secondary shield of the output transformer at the preamplifier end and to the Control enclosure at the other end. Do not ground the shield at the preamplifier. Strain reliefs for the cables must be used.

OPERATION

The excitation amplifier and matching transformers provide a two-phase, 2.5 kHz input power source of the Inductosyn slider or stator. Refer to Figure 4 for the elementary diagram of the matching transformers. The output of the Inductosyn scale is a phase-modulated signal having a nominal frequency of 2.5 kHz. The phase of the signal is proportional to the position of the motion.

The preamplifier amplifies this output to about 8 volts peak-to-peak. The elementary diagram for the preamplifier is shown in Figure 5.

The input transformer (T1) matches the source impedance to the output of the first gain stage, Q1. Voltage regulator (REG1) provides a noise-free voltage for the critical first stage (Q1). R12 and C1 form an RC filter to filter out the spikes to avoid overloading Q1. Q1 is a low-noise field effect transistor. Its gain can be changed by shorting R8 with a jumper. Q1's drain is connected to a LC filter,



CATALOG NO. OF MATCHING TRANSFORMER ASSEMBLY	P.C. BOARD	CATALOG NO. OF P.C. BOARD	T1-T2	TØ MATCH SLIDER AT STATED RESISTANCE OF:	TURNS RATIO OF T1-T2
3N7500SB100E1	1BT1	44A398739-001	44B398002-001	.3Ω TØ .6Ω	1:0.083
3N7500SB100F1	1BT2	44A398739-002	44B398004-001	.8Ω TØ 2.3Ω	1:0.13
3N7500SB100G1	1BT3	44S398739-003	44B398003-001	4Ω TØ 8Ω	1:0.285
3N7500SB100H1	1BT4	44A398739-004	44B398007-001	35Ω TØ 50Ω	1:0.79

ELEMENTARY DIAGRAM FOR THE MATCHING TRANSFORMERS

Figure 4

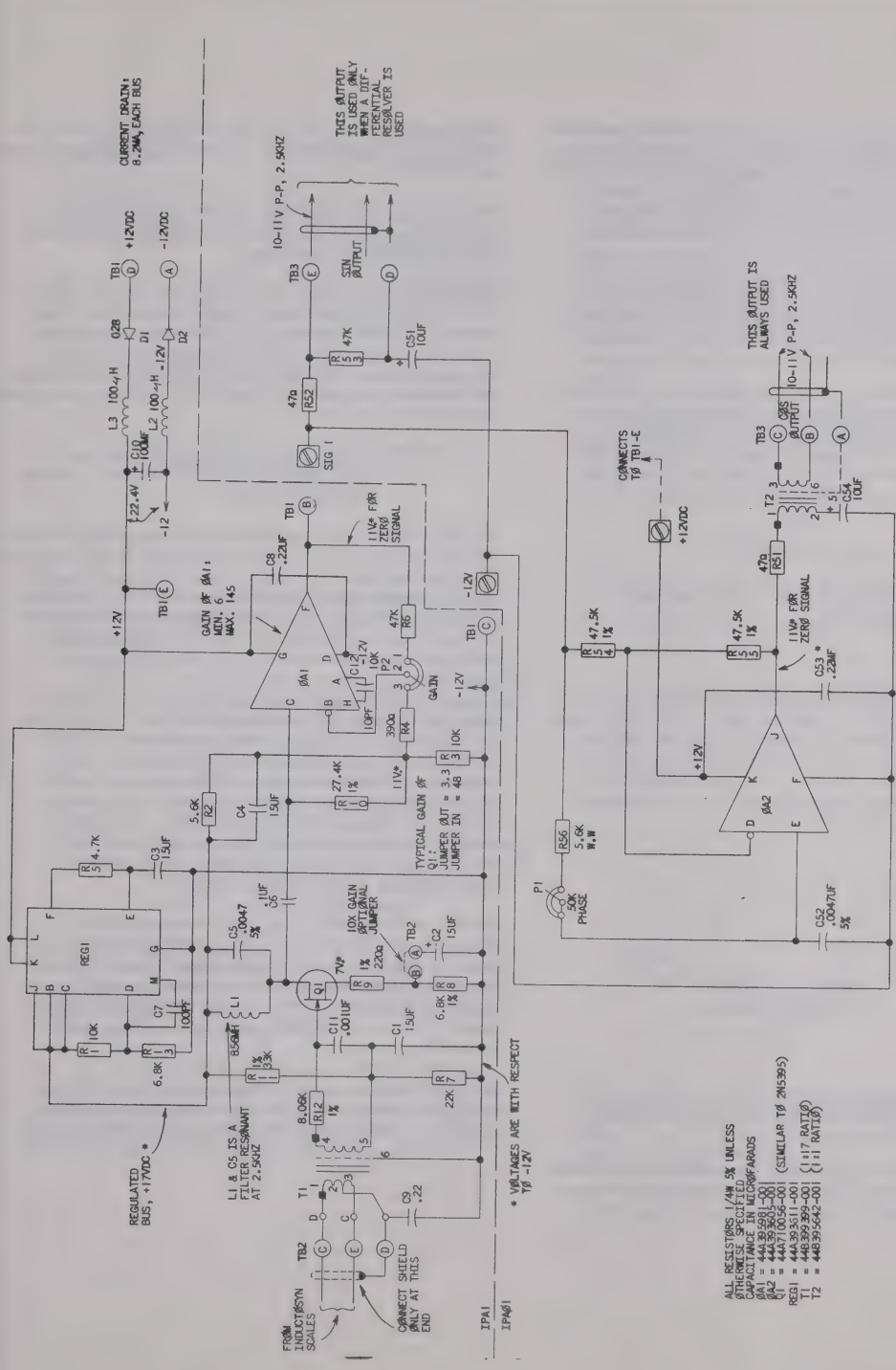


Figure 5.
ELEMENTARY DIAGRAM OF THE PREAMPLIFTER

resonant at 2.5 kHz. OA1 is an operational amplifier whose gain is variable with P2. Its output appears at TB3, E to D. This output is used only if a differential resolver is used. The output of OA1 goes to OA2. The circuit which includes OA2 has a phase shift which can be varied over a 100-degree range by adjusting P1.

When a differential is used, it is adjusted for 90-degree phase shift. When a differential is not used, it is adjusted so that a zero grid point is at a desired place.

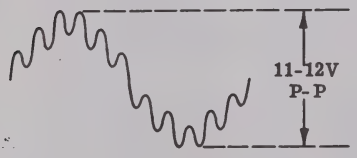
For setup purposes, a full 360-degree zero offset adjustment is obtained without a differential resolver. This is possible because this phase adjustment covers a range of more than 90-degrees; phase can be shifted in increments of 90-degrees by making the proper connections at the matching transformers.

ADJUSTMENTS

Adjustments for gain, relative magnitude and relative phase are as follows:

GAIN

Gain can be changed by a factor of 10 with a jumper across TB2, A to B. The high gain is with the jumper in place. In addition, gain can be changed with the Gain potentiometer, P2, located in the preamplifier assembly. Adjust gain for 11 to 12 volts peak-to-peak as measured at the output of the preamplifier.



RELATIVE MAGNITUDE AND RELATIVE PHASE ADJUSTMENTS

To change relative magnitude, increase the resistance across the primary of one transformer while decreasing the resistance across the primary of the other transformer. Use the Relative Magnitude Adjust potentiometer located on the matching transformer assembly to do this.

The following adjustments rely on the fact that if a cyclic interpolation error occurs, there also occurs a cyclic amplitude variation.

If the Inductosyn scale is moved to change the phase of the feedback signal and if there is a relative magnitude or relative phase error, it causes the amplitude of the feedback signal to change twice, reaching 2 maximum and 2 minimum amplitude points while the feedback changes by 360-degrees. This is referred to as 2-cycle error.

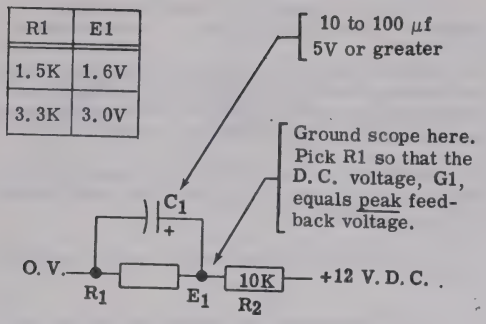
NOTE: A 1-cycle and a 4-cycle error can also exist. See section titled "Troubleshooting", page 13.

To best observe the amplitude variation which is small, we recommend that you use the Accupin Test Accessory. For instructions on its use, refer to the paragraph titled "Accupin Test Accessory", page 10. However, we will proceed here with the assumption that you do not have the Test Accessory and describe an alternate method to observe the amplitude variation.

To observe the amplitude variation, use an oscilloscope with a vertical sensitivity of 5 or 10 millivolts per centimeter. Trigger the scope with a 2.5 kHz reference signal. Observe the filtered sine-wave feedback in the wave shaper. (The place to look for the feedback signal depends on the particular type of Control. It is pin H07 on the AFE1 and AFE2 boards, and it is pin U31, U33 or U36 on the WS31 board.) Adjust the sweep to see approximately 1 cycle of the 2.5 kHz feedback signal.

Set the vertical gain of the oscilloscope to 5 or 10 millivolts per centimeter and use vertical offset so that you can see the tops of the sine waves. If there is not enough vertical offset adjustment, use a battery in series with the ground lead to increase the range, or use a circuit similar to that shown in Figure 6.

To start the adjustments, observe the scope while moving the machine. You should be able to see the amplitude variation of the sine-wave feedback signal.



TEST CIRCUIT USED IN THE ADJUSTMENT PROCEDURE

Figure 6

Adjust the Relative Magnitude potentiometer (P1 in the matching transformer assembly) for minimum 2-cycle error.

NOTE: The correction provided by the Relative Magnitude potentiometer is non-linear with potentiometer rotation. That is, if proper adjustment occurs near the end of the range of the potentiometer, it will be more sensitive to a small rotation than near the center of its range. If you experience this and find it unsatisfactory, connect a 18-25 ohm, preferably wire wound, resistor across terminal board ITB-E to F OR ITB-A to B (Figure 4) as follows:

1. If proper adjustment occurs with the potentiometer turned extremely clockwise (potentiometer viewed from the component side of the printed-circuit board), place the resistor across ITB A to B and move the input wire from ITB A to ITB B.

2. If proper adjustment occurs with the potentiometer turned extremely counterclockwise, (potentiometer viewed from the component side of the printed-circuit board), place the resistor across ITB-E to F and move the input wire from ITB-F to ITB-E.

If minimum error occurs, but some 2-cycle error still exists, the remaining error is phase error. Phase error would rarely occur, but when it does, correct it by adding capacitors either across 1TB-F to D or 1TB-A to C. Trial and error is required to determine the proper terminal board points and the size of the capacitor. A 0.22μf capacitor will correct for an interpolation error equivalent to 1 count. If a capacitor is added to correct for relative phase error, recheck the relative magnitude adjustment. The adjustments cannot be improved if the remaining error varies in a random fashion as the machine motion is moved.

The relationship between amplitude variation and interpolation error is as follows:

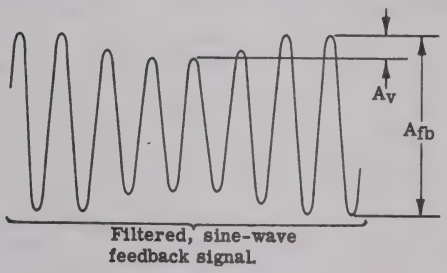
$$Ei \approx \frac{(300)\ Av}{A_{fb}}$$

where:

E_i is the interpolation error in counts.

A_{fb} = Nominal peak to peak amplitude of sine-wave feedback signal.

A_v = Amplitude variation of feedback signal.



Filtered, sine-wave feedback signal.

For example, with a linear Inductosyn scale with 0.1 inch spacing, one count is 100 microinches. Thus, if $E_i = 1$, the interpolation error is approximately 100 microinches.

ACCUPIN TEST ACCESSORY

The Test Accessory (Catalog No. 3N1000TA100B1) is a very useful (although not absolutely essential) aid when adjusting the Inductosyn system.

The ATA2 printed-circuit board in the Test Accessory (TA) amplifies the feedback signal and clips it so that only the very peaks of the sine wave remain. These peaks are then offset so that they occur at the zero-volt level. Then they go to the oscilloscope output of the ATA2 board as well as to a filter within the board to provide the DC output for the strip-chart recorder.

With the Test Accessory, either an oscilloscope or strip-chart recorder can be used. The scope is useful for making the adjustments. The chart recorder could also be used, but you will use more paper.

The chart recorder is especially useful for making a record of the total travel or to evaluate performance. When this is done, you should remember that a correlation exists between amplitude variation and phase error only for interpolation error, not for length error or runout. A change of the DC level of the output of the Test Accessory indicates a change in the spacing of the Inductosyn slider and scale or stator and rotor.

The adjustment procedure when using the Test Accessory is similar to that described in the paragraph titled "Relative Magnitude and Relative Phase Adjustments" page 8 except:

1. The Test Accessory is connected as shown in Figure 7. (The circuit of Figure 6 is not needed.)

2. Connect the scope to the clipped output. Connect the brush recorder to the DC output. Trigger the scope from the scope trigger output of the Test Accessory or from a 2.5 KHz reference in the Control.

3. Set the scope for DC input, and balance the zero offset so that the trace is in the center of the scope for zero volt input.

4. Set the switch on the Test Accessory on the 7500 position.

5. If a scope is used, adjust the gain on the Test Accessory so that sine wave peaks appear at about the zero-volt level of the scope.

6. If a chart recorder is used, adjust the gain on the Test Accessory for 0 volt ± 1V out of the Test Accessory.

7. The relationship between amplitude variation and interpolation error is:

$$\begin{pmatrix}\text{Peak-to-Peak}\\ \text{Cyclic Error,}\\ \text{in counts}\end{pmatrix} = 3.56 \begin{pmatrix}\text{Peak-to-Peak variation,}\\ \text{in volts, of the clipped}\\ \text{or DC outputs.}\end{pmatrix}$$

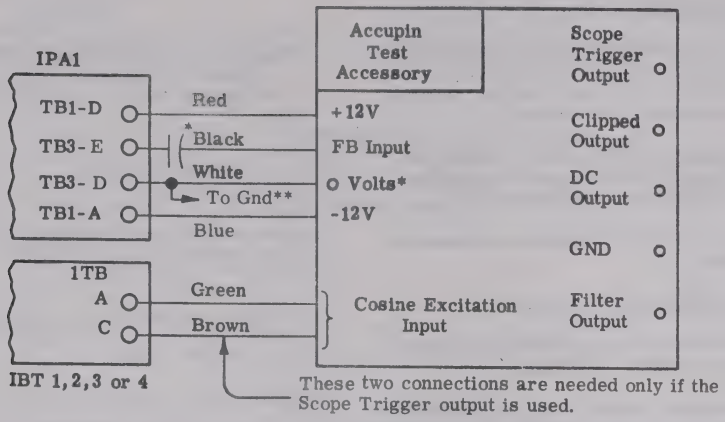


Figure 7 (A)

TEST ACCESORY CONNECTIONS WHEN A DIFFERENTIAL IS NOT USED
(No differential connected at the output of the preamplifier as shown in figure 1)

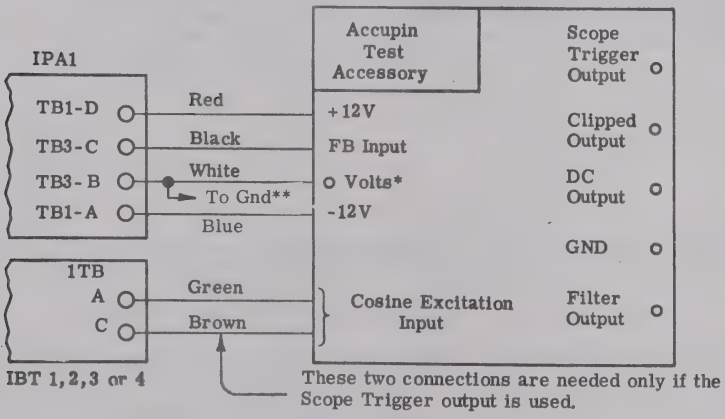


Figure 7 (B)
TEST ACCESSORY CONNECTIONS WHEN A DIFFERENTIAL IS USED.
(When a differential is connected to the output of the preamplifier as shown in Figure 1).

*Capacitor, .01 to 1μf, 50v or greater, non-polarized
** This wire must be grounded; preferably at the backplane in the control.

ZERO OFFSET ADJUSTMENTS

The zero offset adjustment should be made after all other adjustments are made (i.e., after the scales and slider are properly installed, and gain and relative magnitude adjustments are made).

For a given position of the Inductosyn scales, the feedback signal may be shifted in phase more than 90-degrees with the phase potentiometer, P1.

The phase may be shifted in 90-degree increments as shown in Table 2.

Zero Offset with Differential Resolver

The differential resolver is connected in the signal path after the preamplifier, per Figure 1.

Both outputs, sine and cosine, of the preamplifier are used. The phase of the cosine output is variable with respect to the sine output by means of the Phase potentiometer, P1. Adjust P1 for a phase shift of 90 degrees. To make this adjustment, keep the Inductosyn scales stationary. Disable the servos if necessary. While rotating the differential resolver, use a scope to look at the filtered sine wave from the filter in the wave-shaper board, and adjust P1 for minimum amplitude variation.

TABLE 2

CONNECTIONS TO THE MATCHING TRANSFORMER ASSEMBLY TO SHIFT ZERO POSITION IN INCREMENTS OF 90 ELECTRICAL DEGREES

Cable Connections to 1TB				These two columns are relative to first entry below.	
RED	BLACK	WHITE	GREEN	Direction of Feedback	Phase Shift
F	D	A	C	+	0
D	F	C	A	+	±180°
C	A	F	D	+	+90°
A	C	D	F	+	-90°
F	D	C	A	-	0
D	F	A	C	-	±180°
C	A	D	F	-	+90°
A	C	F	D	-	-90°

TROUBLESHOOTING

For obvious problems such as a complete loss of feedback, find the defective area by observing the signal from where it is generated to where it ends to find where it becomes faulty. Some of the problems that could be encountered, their possible causes, and how they may be solved, are listed as follows:

PROBLEM	POSSIBLE CAUSE AND SOLUTION
Lack of feedback at output of wave-shaper	There is faulty feedback excitation, matching transformers, or preamplifier. The ±12-volt DC to the preamplifier is reversed. There is a loose connection.
Feedback doesn't change in phase, only in amplitude	Loss of 1 excitation phase.
Excessive jitter in square-wave feedback. (Jitter should normally be less than 1 count.)	1. The grounds are improper. 2. The gain in the preamplifier is set too low. 3. The rubber shock mounts in the preamplifier are faulty. 4. There is excessive noise on ±12-volt buses with respect to ground at the preamplifier. Try to eliminate the noise. If the noise cannot be easily eliminated, try the following. Obtain a polarized capacitor, 100-250 microfarads, 25 volts. Connect it to the IPA01 board (upper board in the preamplifier assembly) with the negative end on the -12-volt screw terminal, and the positive end on 1 of the 4 mounting bolts which hold the board in place. Use crimp lugs on the ends of the capacitor. The 4-mounting bolts are grounded. Take care that they do not get shorted to any conductor on the board.
Excessive interpolation error or amplitude variation of filtered sine-wave feedback	
1. 1-Cycle Error	There is excessive pickup of the excitation signal in low-level feedback cables. Check cable shielding, grounding, and spacing.
2. 2-Cycle Error	Relative magnitude or phase adjustment.
3. 4-Cycle Error	There is distortion in the feedback signal. The gain in the preamplifier is set too high. The preamplifier is defective.
Excessive drift of feedback signal with time and/or temperature	The preamplifier is defective.

COMPATIBILITY OF THE CURRENT INDUCTOSYN ELECTRONICS WITH THE PRECEDING DESIGN

The catalog number of the Inductosyn Electronics described in this instruction book and the catalog number of the preceding design are given below:

COMPONENT	Preceding Design	Current Design
Preamplifier	3N7500SA101A1	3N7500SA101B1
Matching Transformers	3N7500SB100A1	3N7500SB100E1
Matching Transformers	3N7500SB100B1	3N7500SB100F1
Matching Transformers	3N7500SB100C1	3N7500SB100G1
Matching Transformers	3N7500SB100D1	3N7500SB100H1
Differential Resolver (if used)	44B230648-009	44B230648-001 or
	---	44B230648-005

If a differential resolver is not used, the interconnections remain the same. If a differential resolver is used, the interconnections are different. See GEK-14911 for information on the preceding design.

The current preamplifier (3N7500SA101B1) may be used to replace the preceding one (3n7500SA101A1) without changing the remaining components or interconnections. However, other combinations of old and new components are not recommended.

The current preamplifier (B1) has must better noise immunity than the A1 version. Consequently, if an existing system with an A1 preamplifier has too much noise, the A1 preamplifier can be replaced with the B1 preamplifier and the system will achieve most of the noise immunity of the current system.

Note: Use the catalog numbers above which include the preamplifier enclosure. The new printed-circuit boards cannot be used with the old enclosure.

The current matching transformers provide more excitation voltage to the Inductosyn slider or stator than the preceding transformers (about 2 times). They also present a greater load to their driving source. As a result, the current matching transformers cannot be driven by a differential resolver. This is why the differential is connected to the output of the preamplifier for the current system. Another advantage to this connection is that the errors of the differential resolver do not contribute to the cyclic interpolation errors of the Inductosyn feed-back system.

INDUSTRIAL CONTROL DEPARTMENT, GENERAL ELECTRIC COMPANY, WAYNESBORO, VIRGINIA

CHAPTER XIII

SERVOS

HYDRAULIC SERVO WITH AHD5 BOARD

The information concerning the Hydraulic Servo with AHD5 board is presented in four parts:

1. Description and Operation
2. Stability
3. Adjustments
4. Troubleshooting

For information concerning General Electric hydraulic servo packages, refer to GEK-14895 or GEK-14896.

Before reading further, you will find it helpful to study the block diagram shown in Figure 1 in order to see how the AHD5 board relates to the rest of the servo.

SECTION 1
DESCRIPTION AND OPERATION

The AHD5 board is made up of:

1. A high-gain operational amplifier and its associated input and feedback resistors

2. A power amplifier

3. A level sensor circuit which detects an excessive Velocity Error signal

OPERATIONAL AMPLIFIER

The feedback-impedance network (R_1, R_2 and C) of the operational amplifier is shown in Figure 1. The gain from input to output is the ratio of this feedback impedance to the impedance between the input and the summing point. The input impedances are R_{in} and R_t. The output voltage, which can be computed by the formula below, is equal to the input voltage multiplied by the gain. In this formula, Z_f represents the impedance determined by the combination of R_1, R_2, and C.

$$V_a = \frac{Z_f}{R_{in}} V_{in} + \frac{Z_f}{R_t} V_t$$

This relationship holds true because the operational amplifier has low drift and a very high internal gain over a moderate frequency-range.

The operational amplifier, OA1, is an integrated circuit. (See Figure 2, or the elementary diagram, 44C389958, of the AHD5 board). The amplifier balance control, P5, provides a voltage to compensate for any offsets in the operational amplifier and in the power amplifier. Since balance is affected by some of the other adjustments also, it must be rechecked as a final step when adjustments are made to the AHD5.

POWER AMPLIFIER

The power amplifier is a push-pull, Class B amplifier with a single-ended output. A voltage, which is proportional to valve current, is fed back from the output to the input. This feedback voltage, which is connected to the base of Q2, insures that the valve current is accurately controlled by the power amplifier.

LEVEL SENSOR

The Level Sensor monitors the output from the velocity-loop operational amplifier. When this output exceeds a certain voltage, it causes the output at terminal A1 to change from a logic "1" to logic "0".

The trip point can be adjusted from 65 to 150% of rated valve current (3.2 volts to 7.5 volts) by means of the Trip Level potentiometer, P6.

A time delay is provided which may or may not be used. If it is not used, the Level Sensor trips immediately upon sensing an overvoltage; if the time delay is used, the Level Sensor trips if the overvoltage condition continues for 250 to 350 milliseconds.

To "OR" the level-sensor outputs (PinU38) of several AHD5 boards, simply connect them together. The output can go to either an output driver or input synchronizer.

SECTION 2
STABILITY

One method of analyzing a velocity loop is to break it at any point and then determine the gain around the loop back to that point. (Refer to Figure 1.) The velocity loop can conveniently be broken at the tachometer output. The gain can now be considered in two parts:

1. From the tachometer output, V_t, to the AHD5 operational amplifier output, V_a.

2. From the output (V_a) of the operational amplifier through the power amplifier, the valve, the motor, and the tachometer, to the tachometer output, V_t.

GAIN FROM THE FIRST PART

The operational amplifier produces an output voltage, V_a.

$$V_a = \frac{Z_f}{R_t} \quad (V_t) \text{ if } V_{in} = 0 \text{ (See Figure 3).}$$

At low frequencies (that is, when ω is less than $\frac{1}{R_1 C}$, $Z_f = R_1$ since C is essentially an open circuit. For medium frequencies, consider the resistance of R_1 as much larger and the resistance of R_2 as much smaller than the reactance of C. At these frequencies, R_1 is essentially an open circuit and R_2 is essentially a short circuit. (Equal signs are used for simplicity in these equations although, strictly speaking, the equations are approximations.) This circuit is the simple lag-lead type of circuit when the amplifier is viewed from the input side. The gain, V_a/V_t, can now be plotted against frequency.

When logarithmic scales are used, this plot should look like the one in Figure 4.

GAIN FROM THE SECOND PART

The gain, V_t/V_a, gives a plot which is like the one shown in Figure 5. The plots shown in Figures 4 and 5 were taken from output information which is a result of sinusoidal inputs at a number of different frequencies (i.e., ω = 1 radian/second, ω = 2 radian/second, etc.). These plots of gain versus frequency clearly illustrate the effect of system adjustments. The frequency in radians/second is 2π times the frequency in Hertz/second.

The velocity-loop gain, G_V (Figure 6), is the product of the gains shown in Figures 4 and 5.

We can now use the open-loop gain plot referred to as a "Bode Plot" (Figure 6) to consider the two points of concern.

First, it is desirable to get as high a crossover frequency, ω_c, as can be obtained without a tendancy toward instability. The higher crossover frequency gives better response and allows higher position-loop gain. As the crossover frequency is increased, it is brought closer to the hydraulic resonance; this gives more phase shift between input and output. If this phase shift becomes 180° at a gain of unity or greater than unity, unstable operation will be obtained. Looking at the medium frequency-loop gain, $\frac{1}{\omega R_t C} \cdot \frac{V_t}{V_a}$, we see that, for two reasons, the size of the capacitor (C) is the only thing that can be adjusted in order to change this gain and, therefore, the crossover frequency. The reasons are:

R_t must be set to give the required maximum speed

V_t/V_a is fixed by other requirements such as the maximum speed for approximately 80% of the valve rating.

A decrease in C increases the gain only in the sloped part of the plot, as shown in Figure 7. This also moves moves the crossover frequency from ω_{c1} to ω_{c2}.

The second point of concern is getting the high frequency gain up without bringing the peak of the hydraulic resonance at ω_h too high. Increasing R_2 has the effect (shown in Figure 8) of moving the plot to the broken line.

An increase in the value of R_1 increases the low frequency gain and decreases any final positioning error. As this adjustment has little or no effect on stability, it should be set to and left at its maximum value.

Additional details associated with the Bode Plot are shown in Figure 9.

POSITION LOOP

The block diagram of the position loop is shown in Figure 10, where the closed velocity loop is treated as a single element. The closed velocity loop, which has a frequency-response curve of the type shown in Figure 11, has a flat gain curve nearly out to ω_m. The ω_m frequency is near the crossover frequency, ω_c, of the open velocity loop discussed on page 3 under "Position-Loop Gain".

If the closed velocity loop is treated as an element in the position loop so that the output is position rather than velocity, the closed velocity loop can be treated as another block in the position loop. The other blocks in the position loop represent only pure gain terms (not varying with frequency) in the frequency range of interest. The ripple filter in the position-loop amplifier feedback is not included, as it has a time constant of only about 0.001 second. The open position-loop gain has the same shape as that shown in Figure 12. The effect of increasing

the gain with the gain control is shown by the broken line in Figure 12.

As the gain is raised, the position-loop crossover frequency, ω_c, approaches ω_m of the closed velocity loop, giving more phase shift at ω_c; this results in overshoot when a step input is used. The expected velocity constant K_v, is discussed in the following paragraph.

POSITION-LOOP GAIN

The open-loop gain of the position loop at $\omega = 1$ as shown in the plot of Figure 12, is called the "Velocity Constant" (K) because it is the ratio of the Velocity to the position error required to obtain it. It is easily measured by running a motion at a given feed rate and measuring the "error" between command and position. If, for example, the feed rate is 20 inches/minute and the error is 0.010 inch (that is, 10 mils), we speak of the velocity constant as being 2 inches/minute/mil or, more commonly, 33 radians/second/radian. A K_v of 2 inches/minute/mil should be obtainable without overshoot in most servos. However, 1 inch/minute/mil would be entirely satisfactory. The position-loop crossover frequency, ω_c, in radians/second is equal to the K_v in radians/second/radian. In our example, ω_c would equal 33.

A typical velocity-loop crossover frequency would be 75-100 radians/second.

SECTION 3

ADJUSTMENTS

Before making adjustments, be sure to:

Match the Power Amplifier and the Valve Current-Ratings

Take steps to help insure safe operation during installation

MATCHING THE POWER AMPLIFIER AND VALVE CURRENT RATINGS

Fixed resistors must be selected to match the Power Amplifier and Valve Current ratings.

RESISTOR SELECTION FOR VALVES USED MOST FREQUENTLY

DIFFERENTIAL CURRENT RATINGS (MILLIAMPS)	RESISTANCE PER COIL (OHMS)	COIL CONNECTION	TOTAL RATED CURRENT (MILLIAMPS)	CALCULATED VALUE OF R33, R36 AND R35 IN OHMS (SELECT RESISTORS WITHIN 10%. TWO RESISTORS IN PARALLEL MAY BE USED IF NECESSARY.)	
				R33 and R36	R35
15	200	Parallel	15	200	133
40	80	Parallel	40	75	50
80	22	Series			
200	22	Series	100	30	20

To calculate R33, R36 and R35 for other valves, use the following formulas and pick the resistor having the nearest standard value within 10% of the calculated value. The AHD5 board can drive valves having a current rating up to 400 ma and a maximum of 5 volts across the valve.

$$R33 = R36 = \frac{3 \text{ VOLTS}}{(\text{TOTAL RATED VALVE}) \text{ (CURRENT IN AMPERES)}}$$

$$R35 = \frac{2 \text{ VOLTS}}{(\text{TOTAL RATED VALVE}) \text{ (CURRENT IN AMPERES)}}$$

STEPS TO HELP INSURE SAFE OPERATION DURING INSTALLATION

1. Turn the AC gain potentiometer (P3) to minimum.

2. Make sure that the lag capacitance is at least 3 mfd.

3. Turn the DC Gain potentiometer (P4) to maximum.

4. Open the cross-port damping valve on the valve manifold and turn the Maximum Speed potentiometer (P2) to minimum. (Some drives may not have a damping valve).

TRIP LEVEL ADJUSTMENT

A Trip Level potentiometer, P6, is provided on the AHD5 board. In order to use this potentiometer, there must be a screw in screw-shortable terminal "A". If a screw "A" is removed, an external potentiometer must be used.

Adjust P6 for the desired tripping point. If the Level Sensor is used to stop the machine only when an emergency valve overcurrent condition exists, the potentiometer may be turned fully CCW, so that the Level Sensor trips at 150% of rated valve current.

In using a time delay of 250 ms to 350 ms, make sure that there is a screw in screw-shortable terminal "D" but none in "C". If delay is not wanted, make sure that a screw is in "C" and none in "D".

BALANCE ADJUSTMENT (Figure 1)

1. If the valve has a mechanical null adjustment, remove the electrical connections and set the adjustment to obtain zero motion only if drift exceeds 5% of the top speed. Mechanical null should be centered in the range which gives zero speed.

2. Make the amplifier balance adjustments with the input (terminal P1) either at zero volts or grounded.

3. Turn the hydraulic power off; then connect the tachometer feedback.

4. Adjust P5 for 0 ± 0.05 volt from Terminal D2 to terminal C2. (Although this is an easy adjustment to make, it is not necessary to maintain this tolerance for long-term changes, since even 0.5 volts of imbalance corresponds to an error of only approximately 0.0001 inch.)

ADJUSTMENT OF THE MAXIMUM SPEED POTENTIOMETER

The Maximum Speed potentiometer, P2, and resistor R3 are used to give the desired maximum speed with the maximum obtainable voltage at the output of the position-loop amplifier.

Any desired resistance may be placed across terminals T13 and T14. (See Figure 2.) The minimum tachometer resistance is 9.4 K. Potentiometer P2 has a range of 0 to 50K ohms. The maximum tachometer resistance depends on the resistor selected for R3.

In order to make the maximum speed adjustment, program a feed rate which is equal to half of the maximum speed, and adjust P2 and R3 so that half of the maximum voltage is present at terminal P1 on the AHD5 board.

STABILITY ADJUSTMENTS

There are two amplifier adjustments which affect the stability of the velocity loop:

1. Varying the value of the Lag capacitor (C)

2. Setting the AC Gain Adjustment potentiometer (P3) and selecting the proper resistance for R50 (across T5 and T6).

Most systems also have a cross-port damping valve adjustment on the valve manifold.

The DC gain potentiometer, P4, is normally set at maximum. The resistance of R6 (across T15 and T16) is normally 2 megohms.

While observing the tachometer voltage on a strip chart recorder and moving the servo in short steps, note that if the servo is not torque-saturated, the strip charts showing velocity response to step inputs of different amplitudes are similar. If the servo is torque-saturated, the strip charts are different. In this case:

1. Make the adjustments for zero overshoot at about 50% of the rated speed.

2. Make a check using a step input that results in maximum speed to be sure that the overshoot is no more than 10-20%. (Minimize the overshoot when the machine is approaching top contouring speed.)

In some Controls, because the jog pushbuttons work in a closed position loop, they introduce ramp inputs rather than step inputs of velocity. Because a steep ramp function gives almost the same result as a step function, use jog pushbuttons instead of a special hookup. If you do not use pushbuttons to place steps in the velocity loop, use a Step Function signal. (See Figure 15 for a circuit that can be used for this purpose.)

If the servo has previously been adjusted, the position-loop gain adjustment will probably be satisfactory for a velocity-loop adjustment. If you are making the initial adjustment, it is necessary to find a setting of position-loop gain which is low enough to avoid oscillation. After having made the first adjustment of the velocity loop, set the position-loop gain in accordance with the instructions entitled "Position-Loop Gain" (page 3).

Check the time constant of the filter in the feedback circuit of the position-loop amplifier to make sure that it is correct. (Refer to the system Elementary Diagrams for the location of the board.) The RC product should be in the range of 0.005 to 0.001 second.

ADJUSTMENT OF THE LAG CAPACITOR

The capacitors supplied with the AHD5 board allow capacitance to be adjusted from 1 mfd to 3 mfd in steps of 1 mfd each. To change capacitance, remove the undesired capacitors from the board. (Save the removed capacitors for use in some other Control that may need extra capacitors.)

There is space on the AHD5 board for two, 5 mfd, metallized paper capacitors (GE #983B532J60). In the event that more capacitance may be needed, you may add capacitors external to the board. (More capacitance is rarely needed.) Jog or run the machine motion for a small distance and observe the tachometer voltage on a strip-chart recorder. (Typical strip charts illustrating the effect of lag capacitor adjustment are shown in Figure 13.)

AC GAIN ADJUSTMENT

Adjust the AC gain by means of potentiometer P3 and selectable resistor R50, so that the gain is high enough to prevent sluggish operation, yet low enough to prevent oscillation at the hydraulic resonant frequency.

Strip charts illustrating the effect of gain adjustment are shown in Figure 14. Although adjustments to the cross-port damping valve will accomplish the same thing as an adjustment of P3, too much damping will cause a "deadband" and decrease the positioning accuracy.

Ripple voltage from other sources should not be confused with the effect of the hydraulic resonance described above. The oscillations from the hydraulic

resonance can be damped out but will be present in both the step-to-speed and the step-to-stop operations. For further discussion of ripple voltage, see page 7.

DITHER

Sometimes dither may be required (screw "A" in). The AHD5 board was originally built with a .01 mfd capacitor (C10) across terminals T17 and T18. This results in a dither frequency of approximately 600 Hz. If dither having this frequency is not suitable, capacitor C10 can be changed in value to generate a dither anywhere in the range of 40 to 1000 Hz. To select the capacitor for the frequency desired, use the following approximate formula:

$$C \text{ (in MFD)} = \frac{6.25}{\text{Frequency in Hz.}}$$

Potentiometer P1 on the AHD5 board controls the dither amplitude.

External dither may be used by removing screw E.

DITHER ADJUSTMENT

1. Before adjusting the dither amplitude, ground input Pin L38.

2. Measure the peak-to-peak voltage at Pin L31 with an oscilloscope, and adjust P1 to the desired amplitude. (If an oscilloscope is not available, estimate the dither amplitude by observing the setting of P1. Dither amplitude is proportional to the position of P1. When P1 is fully clockwise, the dither amplitude is about 0.5 volts (peak-to-peak). If no dither is required, turn potentiometer P1 fully counterclockwise. Too little dither may cause a hunting condition in the closed-loop system; too much will cause excessive wear on the servo valve.

If you are using dither while making stability adjustments, you may find it advisable to use more than the normal amount of dither in order to eliminate the possibility of instability caused by insufficient dither or absence of dither. After having made the stability adjustments which are described on page 5, be sure to return the dither amplitude on P1 to its optimum value.

After completing the dither adjustment, remove ground from Pin L38 of the AHD5.

SECTION 4

TROUBLESHOOTING

Although this section cannot cover every possible malfunction for an AHD5 board, it will be helpful in troubleshooting the hydraulic servo package.

Expected performance may not be obtained if the following conditions exist:

1. Too much ripple

2. Oscillation which cannot be eliminated by adjustment

3. Failure to move on a small error signal

4. Faulty AHD5 amplifier

TOO MUCH RIPPLE

The rms ripple from the tachometer commutator should not exceed 3% of the tachometer output voltage at speeds in excess of 100 rpm. The ripple frequency can be expected to be equal to or double the number of bars per revolution in the commutator of the tachometer. If the tachometer ripple is above 4%, replace the tachometer.

If the cross-port damping valve is closed too far, ripple may be observed due to pressure variations in the hydraulic motor. This will be 4 cycles per revolution for the Hartman motor and 42 cycles per revolution for the Char-Lynn motor.

OSCILLATION WHICH CANNOT BE ELIMINATED BY ADJUSTMENT

Loose tachometer coupling or loose resolver coupling can cause oscillation which cannot be eliminated by adjustment. Note that there must be essentially no lost motion between the tachometer and the servo. Oscillation caused by a loose resolver coupling will be of a lower frequency than that caused by a loose tachometer coupling.

FAILURE TO MOVE ON A SMALL ERROR SIGNAL

Failure to move on a small Error signal can be caused by one of the following conditions:

1. High friction caused by tight gibs. High friction causes slower than normal accelerations and faster than normal stops.

2. Low pressure which also gives slow accelerations but normal stops.

3. Damping valve opened too wide.

4. Defective amplifier (Try changing the AHD5 board.)

5. Position-Loop gain set too low (See "Position Loop Gain" on page 3.)

FAULTY AHD5 AMPLIFIER

If you think an amplifier is defective, replace it with one which is being used for another motion. Follow the checking procedure only if the amplifier is still questionable.

Checking Procedure

In order to check the gain of the operational and power amplifiers and the operation of the Level Sensor circuit, proceed as follows:

1. Turn the hydraulic power OFF.

2. Make sure that the inputs at Pins L06, L38 and L19 are disconnected or that they are at zero volts.

3 Make sure that the output at Pin L31 can be balanced by turning P4.

4. To check the Gain and the Level Sensor circuit:

Find a resistor about equal to twice the resistance of P4 + R6. Connect it from Pin L06 to the ±12 volt bus.

The voltage at Pin L31 should be plus or minus 2.4 volts, depending on the bus used to connect the resistor. The voltage at the output (Pin L36) of the operational amplifier should be plus or minus 6 volts.

With P6 fully counterclockwise, the output of the Level Sensor should be at logic 1; but when P6 is turned clockwise, the output of the Level Sensor should go to logic 0.

Isolating the Faulty Component

Locate the faulty component by measuring voltages and comparing them with the voltages shown on the Elementary Diagram.

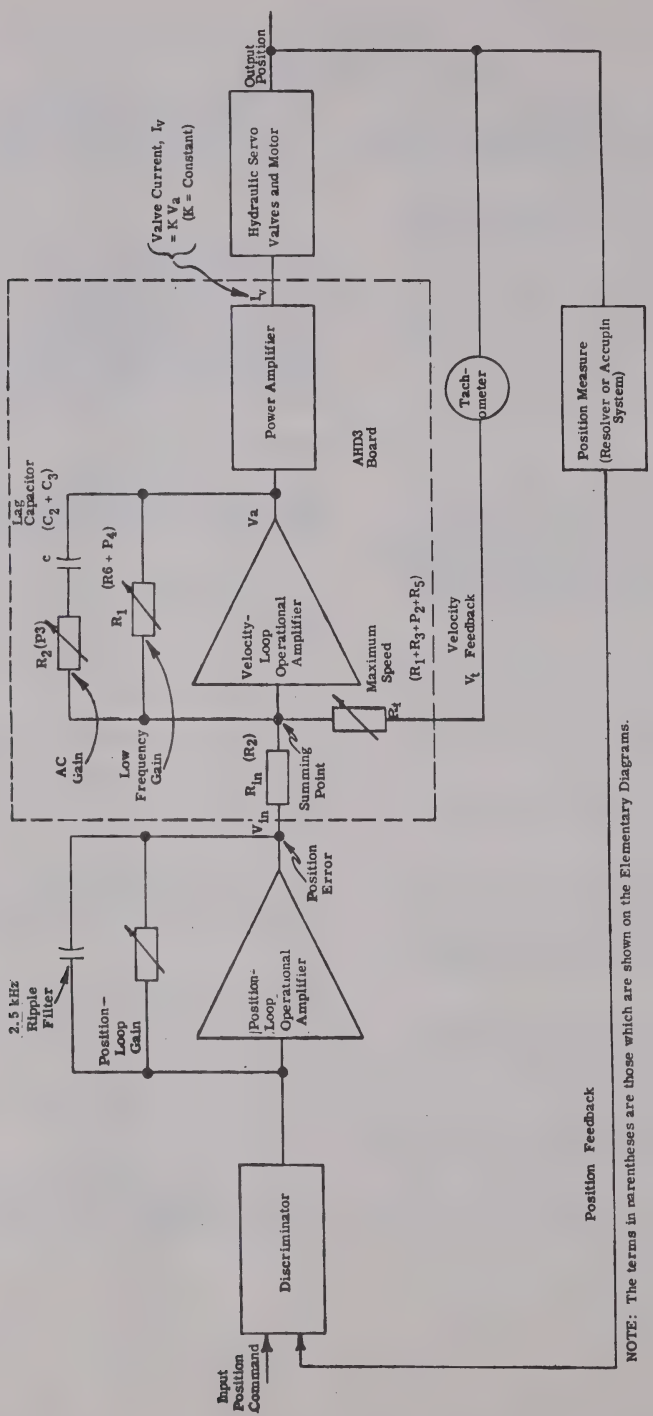


Figure 1.
BLOCK DIAGRAM OF HYDRAULIC SERVO

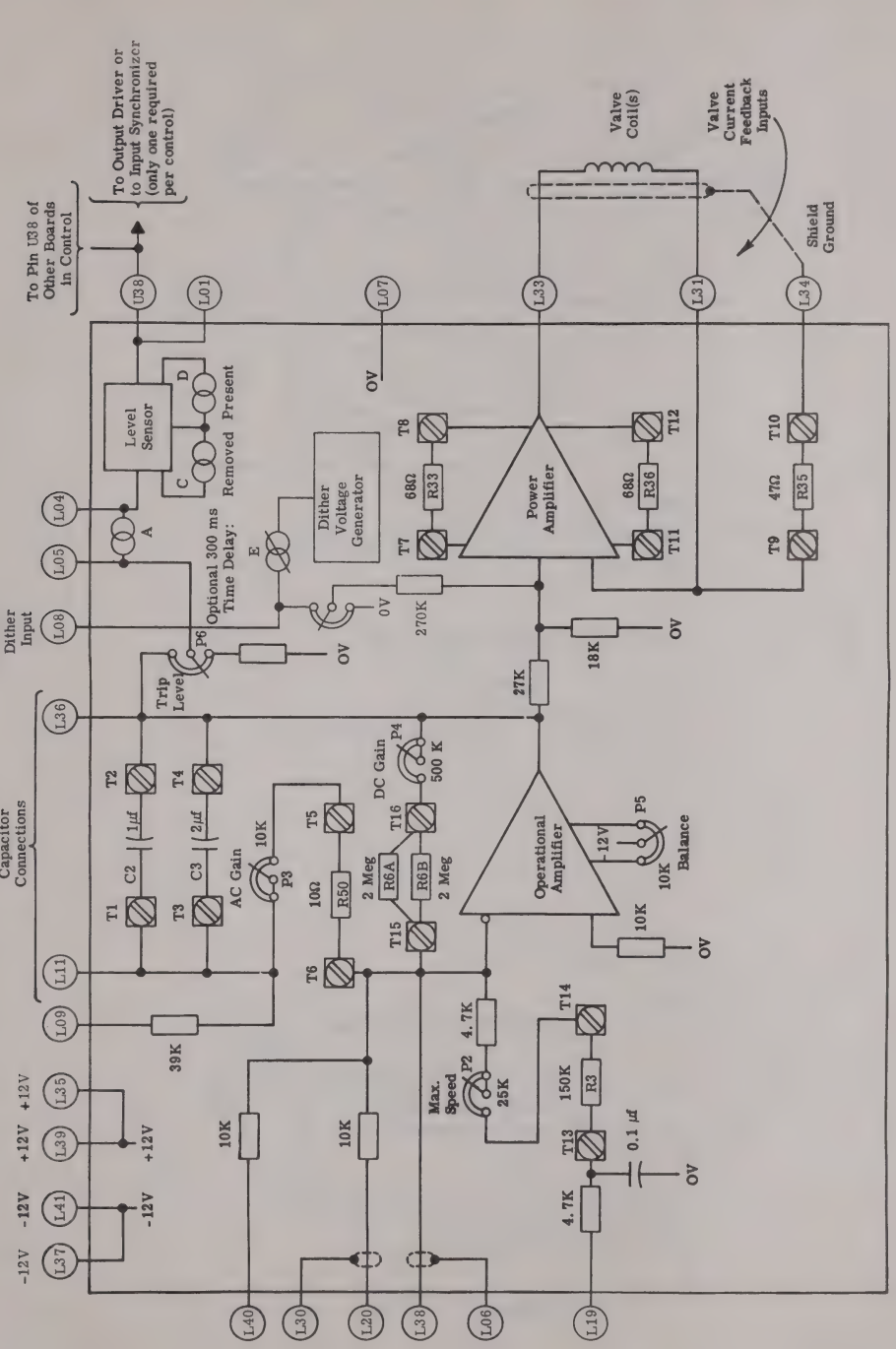
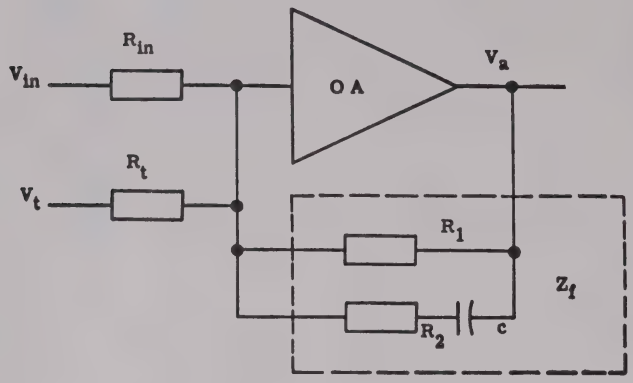


Figure 2
FUNCTIONAL DIAGRAM OF AXIS HYDRAULIC DRIVE, AHD5 BOARD



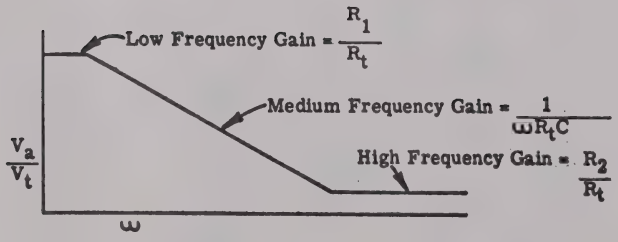
For low frequencies: $V_a/V_t = R_1/R_t$

For medium frequencies: $V_a/V_t = X_c/R_t = 1/\omega CR_t$

For high frequencies: $V_a/V_t = R_2/R_t$

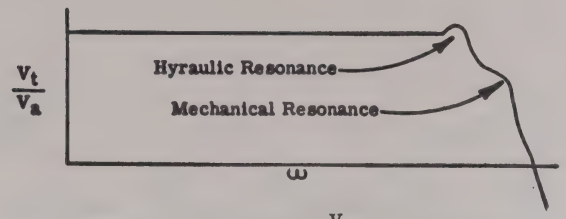
SIMPLIFIED REPRESENTATION

Figure 3



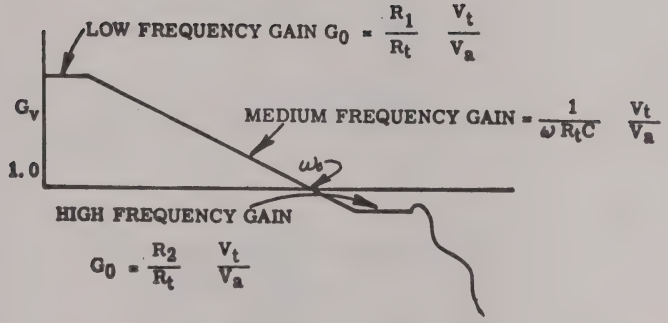
PLOT OF $\frac{V_a}{V_t}$

Figure 4



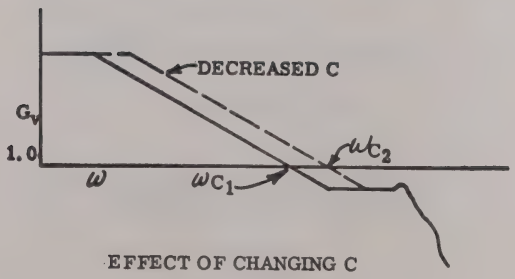
PLOT OF $\frac{V_t}{V_a}$

Figure 5



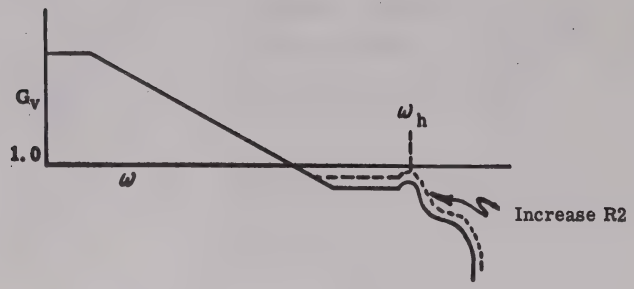
VELOCITY-LOOP GAIN, G_v

Figure 6



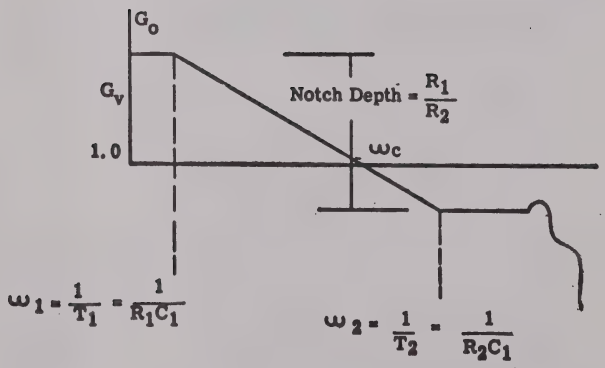
EFFECT OF CHANGING C

Figure 7



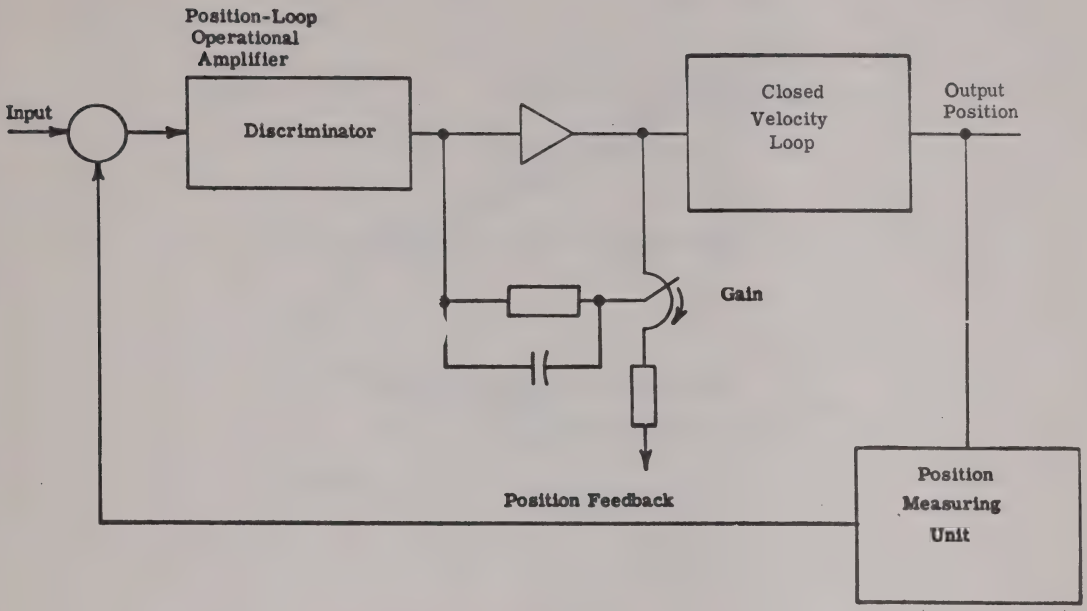
INCREASING HIGH FREQUENCY GAIN

Figure 8



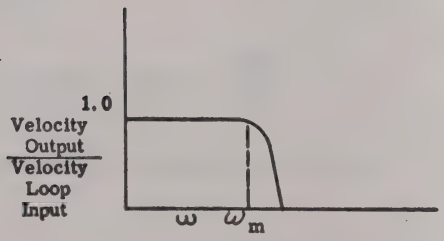
ADDITIONAL BODE PLOT DETAILS

Figure 9



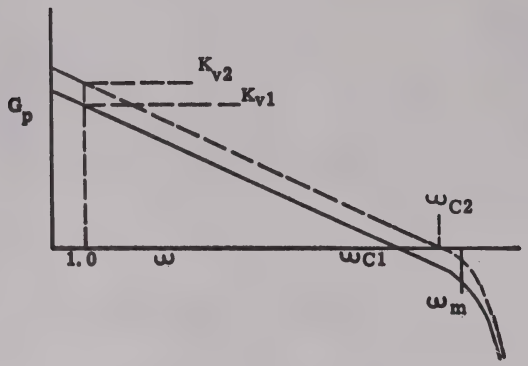
BLOCK DIAGRAM OF POSITION LOOP

Figure 10



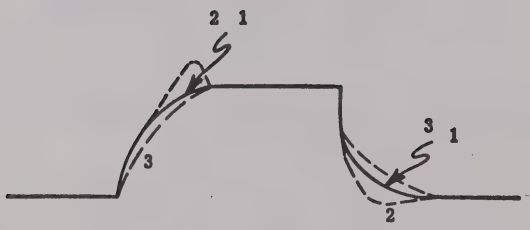
PLOT OF FREQUENCY-RESPONSE CURVE FOR
CLOSED VELOCITY LOOP

Figure 11



PLOT OF OPEN POSITION-LOOP GAIN

Figure 12



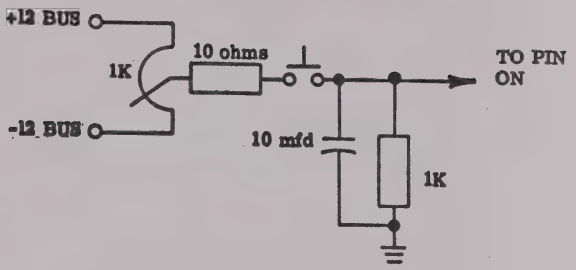
1. GOOD
2. LAG CAPACITOR TOO SMALL
3. LAG CAPACITOR TOO LARGE

EFFECTS OF ADJUSTING LAG CAPACITOR

Figure 13

EFFECTS OF AC GAIN ADJUSTMENT P3

Figure 14



STEP FUNCTION SIGNAL SOURCE

Figure 15

CHAPTER XIV

POWER SUPPLIES

12
.02
.24

REGULATED POWER SUPPLY AND BATTERY CHARGER SERIES 3N8100PS102A1 AND A2 (+12V, +5V, AND -5 VOLTS)

The PS102 power supply converts power from an unregulated, single phase, 50/60 Hz AC line or a 12V battery to DC power as shown below.

TABLE 1

INPUT VOLTAGE	VOLTAGE AND TOLERANCE	CURRENT
115V + 10% - 15% 50/60 Hz -OR- 48 V + 10% - 15% 50/60 Hz	+12 ± 2% + 5 ± 2% - 5 ± 2%	0.8A 2.4A 35 ma
+10.5 to +14.5 D.C.	+12 ± 2% + 5 ± 2% - 5 ± 2%	0.8A 2.4A 35 ma

The power supply is used in a solid state memory system which must be maintained for various periods of time when AC power has been removed. When AC power is removed, the memory load is automatically transferred to the battery. When AC power is restored, the load is transferred back to the DC source derived from the AC input. The battery is automatically recharged when AC power is restored. Additional batteries may be connected to the supply to increase the length of time that the memory will be maintained following the loss of AC power. Refer to table 4 (page 9) for operating times and to Battery Maintenance, page 8 prior to adding batteries.

The power supply is equipped with protective circuits which provide:

1. Fusing to protect the batteries and wiring if the battery circuit becomes shorted. (See Figure 2, page 30, FU2.)

2. Fusing to protect the preregulator against overload conditions. (See Figure 2, page 30, FU1.)

3. An undervoltage detector on the REG8 board which provides an indication when an undervoltage, as shown in Table 2, occurs at its output.

TABLE 2

OUTPUT VOLTAGE	MAXIMUM UNDERVOLTAGE ALLOWED
+12	+11.3
+ 5	+ 4.7
- 5	- 4.6
Battery	+10.2

4. An overvoltage protector on the REG8 for the +12V, +5V, and -5 volt outputs.

The PS102 power supply includes:

1. A power transformer.

2. Fusing to protect against supply failure.

3. A heat sink assembly which contains SCR's, power diodes, and a preregulator circuit (power transistors).

4. A BCR1 printed-circuit board contains battery charger circuits. This board controls the externally mounted SCR's.

5. An REG8 printed-circuit board contains memory protect circuits, series pass regulator to provide a -5 volt output, and two switching regulators to provide +12, and +5 volt outputs.

Refer to Figure 1 for a block diagram of the circuit and to Figure 2A for information concerning assembly, components and terminal locations.

INPUT TRANSFORMER

The input transformer (T1) converts AC input voltage to the lower voltages required by the preregulator supply and battery charger. See the Transformer tables: Figure 2, page 14, and Figure 2B, page 16. Jumper connections on 221TB, as shown below, permit operation from a 115V or 230-volt input.

TABLE 3

INPUT VOLTAGE	INPUT TERMINALS	JUMPER CONNECTIONS
115 VAC 50/60 Hz	C and E	A to B C to D
230 VAC 50/60 Hz	E and D	C to B

The input transformer has 2 center-tapped secondary windings which provide AC voltages for 4 full-wave power-rectifier circuits. The secondary windings connect to terminals on terminal board 222TB and to terminals on the BCR1 printed-circuit board.

PREREGULATOR

The Preregulator is a series (control) regulator which supplies power to the REG8 board when AC power is available. The regulator consists of power transistors Q1 and Q2, zener diode BD1, and resistors R5 and R6. Transistors Q1 and Q2 are mounted on the heat sink which is located on the supply panel. Diode BD1 and resistor R6 are mounted on 225TB. Resistor R5 is mounted on a standoff which is located on the supply panel.

Transistors Q1 and Q2 are connected in a Darlington emitter-follower configuration. Drive current to transistor Q1 is supplied through resistor R6. Resistor R5 limits the current flow and power dissipation in transistors Q1 and Q2.

Zener diode BD1 is an 18V diode which establishes a reference voltage on the base of transistor Q1. The emitter of transistor Q2 is 2 V_{BE} drops below the 18V reference or approximately +16 volts. Since the voltage which is applied to the collectors of the transistors is unfiltered, the transistors do not conduct continuously but in a pulsating manner. The voltage produced at the emitter of Q2 is filtered by capacitor C1 which is mounted on the supply panel. Power is supplied to the preregulator from a full-wave rectifier circuit comprised of diodes D1 and D2 which are mounted on the panel heat sink.

Diode D3 is a diode switch that permits the inputs to the REG8 to be automatically transferred from the preregulator to the battery circuit when AC power is removed. When AC power is available, the voltage at the emitter of Q2 is higher than the battery voltage; hence, diode D3 becomes reverse biased and the preregulator supplies power to the load. When AC power is removed, the preregulator turns off and current flows from the battery through diode D3 and to the load. The REG8 board is the load which is supplied either by the preregulator or the battery.

BATTERY CHARGER (Figure 3)

The battery charger consists of:

1. A BCR1 printed-circuit board.

2. Two SCR's and a power diode which are mounted on the PS102A1 heat sink.

3. An inductor mounted on PS102A1.

4. A 100 mf capacitor mounted between 224TB-E and 224TB-A on PS102A1.

The BCR1 board in conjunction with the heat-sink mounted SCR's is used to fullwave rectify and regulate a voltage that is used to charge from 1 to 4 parallel-connected, 12V, 20AH, GEL/CELL *batteries. Four outputs are provided for connecting the positive terminal of each battery to the PS102A1 supply. Terminal board 223TB, terminals A, B, C, and D, are used for these connections.

*Registered trademark of Globe-Union, Inc.

The negative terminals from all batteries are connected to terminal 223TB-E on PS102A1.

OPERATION

Battery charging is accomplished in 3 modes of operation, namely, Current Limit mode, Voltage Limit mode, and Float Voltage mode. The charger automatically enters the correct charging mode by sensing the battery conditions.

1. In the Current Limit mode, charging current to each battery is sensed and limited so that the maximum current to any one battery will not exceed 4.0 amps (average). Although the currents are individually sensed, they are not individually controlled; hence, the voltage required to maintain 4.0 amps of charging current to one battery may not be sufficient to maintain 4.0 amps to the other three. When the charging current to all batteries is less than 4.0 amps, charging time is extended. Normally, all the batteries in a system will have gone through the same number of recharge cycles; therefore, their charging currents will be approximately the same.

2. In the Voltage Limit mode of operation, ($4 > I > .200A$) the charger voltage is maintained at approximately +14.4 volts. This voltage is maintained until the charging current to all batteries is less than 200 ma. Individual sensing circuits permit monitoring the charge current to each battery. A battery is considered fully charged when the charging current drops below 200 ma while maintaining the charging voltage at +14.4 volts. After all batteries reach full charge, the Float Voltage mode is entered.

3. In the Float Voltage mode, ($I < 200$ ma) the charger output voltage is reduced to +13.65 volts. Maintaining a float voltage of +13.65 volts on the batteries keeps them in a fully charged condition.

Note: Batteries which have been fully discharged require approximately twelve hours of charging to reach a fully charged condition.

BCR1 PRINTED-CIRCUIT BOARD (Figure 3)

A typical external circuit for the operation of BCR1 is shown on drawing #44C285360, sheet 1. Waveforms are shown in Figure 4.

The BCR1 board in conjunction with externally mounted SCR's is used to full wave rectify and regulate a voltage that is used to charge from 1 to 4, parallel-connected, GEL CELL batteries. Input power to the board is supplied from a 28-VAC center-tapped transformer. Input frequency may be either 50 or 60 Hz.

OPERATION

In order to provide voltage for the buses of the BCR1 and to generate a synchronous controlling signal for the external SCR's, the line voltage is transformed to a 28-VAC center-tapped voltage, which becomes the incoming voltage for the BCR1 board. This voltage is full-wave rectified by diodes D1 through D4 to produce DC voltages. The full-wave rectified voltage is also applied to the base circuit of transistor Q1 through resistor R2. For the period when the rectified sine wave is below 0.7V, Q1 turns off, and the voltage at its collector rises to the voltage determined by zener diode BD1. Capacitor C2 charges to the voltage determined by BD1 thus producing a sawtooth waveform. The discharge rate of capacitor C2 is controlled by the output voltage of the regulating amplifier OA2. The discharge time determines the time during the cycle at which transistor Q2 turns off. As the control voltage out of OA2 is varied, the time during the cycle at which Q2 turns off is also varied, thus advancing or retarding its output with respect to the incoming line reference. The output of the amplifier comprised of transistor Q2 and resistor R7 is connected into base of transistor Q3. Transistor Q3 drives 2 PNP transistors (Q4 and Q5) which in turn provide drive current into the gate input of separate controlled rectifiers, thus initiating conduction of an SCR during each half cycle of the incoming power. The output from the SCR's (not part of BCR1) is filtered to produce a DC voltage of approximately 13.65V when in the Float Voltage Mode.

To provide a closed loop system where the DC voltage is kept constant, a sample of the output voltage is sensed at the junction of R18 and R19 and compared with the reference voltage across zener diode BD2. Regulating amplifier OA2 is polarized such that an increase in output voltage produces a decrease in the conduction angle of the SCR's thus keeping the output constant within ±3%.

A current limit circuit provides protection for the power circuits and also limits the current that may be supplied to the batteries being charged. Current is sensed by monitoring the voltage drop across a 0.1-ohm resistor which is placed in series with each battery. The voltage sensed is a pulse of approx-

imately 0.4V. These pulses are amplified by amplifiers OA4 through OA7. The outputs from these amplifiers are connected to 2 four-input diode gates. The output from each diode gate is then filtered by a 10 mfd capacitor and applied to the input of a comparator circuit. Comparator OA3 senses maximum current as determined by Potentiometer P2 and produces a positive voltage at its output when the limit is exceeded. The output of OA3 is connected to the input of the regulating amplifier OA2. This input overrides the voltage sense input to OA2, causing the DC output voltage to be reduced until the current limit is no longer exceeded. Comparator OA1 senses the voltage across capacitor C4 to determine when the battery charge current has fallen to approximately 200 ma thus indicating that the batteries have been fully charged. When full charge is detected the output from OA1 goes positive, transistor Q6 turns on, and the current into reference junction between R18 and R19 is reduced, causing the output voltage to shift from approximately +14.3 volts to 13.65 volts.

A soft start circuit is comprised of resistors R30 and R31, diode D11, and capacitor C6. C6 is initially in a discharged state and pulls the junction of R6 and R32 positive when power is applied, thus permitting the conduction angle of Q2 to increase gradually as C6 charges to a negative voltage. When C6 has charged to a negative voltage, diode D11 is reverse biased and the soft start circuit no longer influences circuit operation. Diode D10 provides a discharge path for capacitor C6 when power has been removed.

Adjustments

Voltage adjustment (P1) provides a facility to adjust the DC voltage produced by externally mounted SCR's. Nominally, the DC voltage is adjusted to 13.65 volts when load current is 200 ma or less per battery.

Adjust the battery charger DC output voltage.

1. Disconnect all batteries and place a 120-ohm, 2-watt, resistor from terminal 223TB-A to 223TB-E.

2. Place the DC voltmeter from terminal 223TB-E to 224TB-A.

3. Adjust potentiometer P1 on the BCR1 board until the meter reads +13.65 volts. Long time constants in the charger circuits cause the output to respond slowly.

4. Remove the resistor and meter.

Current Limit (P2) provides adjustment of current limit for battery charge current and for protecting externally mounted SCR's. Current limit is nominally adjusted to 4.0 amps per battery when batteries are in a discharged state.

Adjust the maximum battery charge current.

1. Disconnect all batteries.

2. Place the oscilloscope ground lead on terminal 224TB-A (THE SCOPE GROUND MUST BE ISOLATED FROM ALL OTHER GROUNDS) and monitor the waveform on terminal 223TB-A while placing a 2.2-ohm, 25-watt resistor from terminal 223TB-A to 223TB-E.

3. Adjust potentiometer P2 on the BCR1 board until a peak amplitude of 0.5 volts is obtained. The waveform is shown in Figure 6. Long time constants in the charger circuits cause the output to respond slowly.

4. Move the 2.2-ohm resistor and scope lead to terminals 223TB-B, 223TB-C, and 223TB-D while observing the waveform at each terminal. The peak amplitude of the wave observed at each terminal will be 0.5V ±0.05V.

5. Remove the resistor and scope. Connect all batteries to the supply.

REG8 PRINTED-CIRCUIT BOARD (Figure 5A thru 5C)

The REG8 board contains the following functions:

1. A +12-volt switching regulator
2. A +5-volt switching regulator.
3. A -5-volt series pass regulator.
4. Overvoltage protector circuit.
5. An undervoltage detector circuit.
6. Input power monitor.
7. Battery monitor circuit.
8. Power fail detector.

9. Voltage booster.

10. A logic and reference supply.

The circuits on the REG8 board are comprised of several types of logic; namely, TTL, CMOS, and linear IC's. Input power is supplied from a 16V DC supply when AC power is available or from a 12V battery when the AC has been removed. Two output terminals are provided for each of the three DC output voltages.

Maximum output currents are as follows:

+12V at 0.8A
+ 5V at 2.4A
- 5V at 35 ma

Operation - REG8

Refer to Figure 5-5C during the following description of operation.

SWITCHING REGULATORS +12V AND +5V

The +12V and +5V regulators are switching regulators that use a variable duty cycle technique to regulate their output voltages. These circuits are shown in Figure 5B. Each circuit is comprised of an integrated circuit voltage regulator, operational amplifier, and discrete components to complete the switching regulator circuits. Since the operation of the +12V and +5V regulators are similar, only the operation of the +12V regulator will be described in detail.

The following is a brief description of each major component in the +12V switching regulator circuit.

Voltage regulator VR3 is an I.C. package that contains a voltage reference, error amplifier, current limiter, and series pass transistor. The VR3 regulator drives transistors Q22 and Q23 which are connected in a Darlington configuration and perform as a power switch. Operational amplifier OA3 is used to sense output current. OA3 provides drive to transistor Q25 when the current limit is exceeded. Transistors Q24 and Q25 provide an inhibit input to VR3. These transistors have their collectors connected in a wired OR configuration such that turning on either transistor will pull pin 13 of VR3 low, thus turning the regulator off. Inductor L2 and capacitor C39 make up an inductor input filter that filters the output voltage. Resistor R101 is a current shunt which provides a means of monitoring the output current.

Operation of the switching regulator is as follows:

Assume that initial startup has been completed and that the output load is constant. A reference voltage of approximately +7.2V is applied to pin 5 of VR3. Pin 5 is the non-inverting input of the error amplifier. The +7.2V is derived by summing the output reference voltage from pin 6 of VR3 with a feedback voltage from the junction of L2 and D12. Resistors R89 and R90 are the summing resistors. The +12V output at 1TB-E is reduced to approximately +7.2V at the wiper of P4 by the voltage divider consisting of R99, P4, and R100. The output voltage is therefore sensed at the wiper of P4. This sense voltage is then applied to the inverting input (pin 4) of the error amplifier in VR3.

Assuming that the transistor switch (Q22 and Q23) has just turned off, the output capacitor (C39) begins to discharge and the error amplifier senses this voltage change. The amplifier then produces an error voltage to turn on the pass transistor in the VR3. Turning on the pass transistor in VR3 provides drive to turn on the power switch consisting of transistors Q22 and Q23. When the power switch turns on, the feedback voltage through R90 causes the voltage on VR3 pin 5 to increase slightly. This increase in voltage causes the error voltage to increase, thus increasing the drive to the power switch. After the power switch has been on for a short period, capacitor C39 begins to charge. As C39 charges, the input voltage to the error amplifier (pin 4) increases, causing the amplifier output to decrease until the power switch is finally turned off. The feedback voltage through R90 decreases causing the voltage on pin 5 of VR3 to decrease slightly. Capacitor C39 begins to discharge and the previous sequence is repeated. The switching frequency is determined by the values of L2, C39, and R90. The frequency of the switching regulator will vary with output loading. The power switch "on" time is approximately 50 microseconds; the "off" time changes with the load.

Over-current protection is provided for VR3 and the power transistors. The VR3 output current is sensed by using resistor R92 as a current shunt in series with its output. The voltage drop across R92 is applied to the current limit circuit internal to VR3. When the voltage across R92 reaches approximately .7V, the current limiter turns off the pass transistor in VR3, thus preventing any further increase in its output current. The power transistors Q22 and Q23 are protected from excessive current by using resistor R101 as a current shunt to monitor output current at terminal 1TB-E. When the output current

increases above 800 ma the voltage drop across R101 is amplified sufficiently by OA3 to cause transistor Q25 to turn on. Turning on Q25 causes the series pass transistor in VR3 to turn off and in turn causes the power switch (Q22 and Q23) to turn off. The current limit action is a fold-over type of limiting such that as the greater the over-current the lower the output voltage will become. When output loading is reduced following an over-current condition, normal regulation is resumed.

Operation of the +5V regulator differs from that of the +12V regulator in the following manner. The reference voltage out of VR2 pin 2 is reduced to +5V by a voltage divider and applied to pin 5 of VR2. The inverting input to the error amplifier in VR2 is connected directly to the +5V output. The switching frequency varies with load; however, the power switch is on for approximately 60 microseconds. The final difference is that the value of the current limit resistor is a lower value of resistance, thus permitting the current limit to be set at approximately 2.5A.

Soft start circuits control the rate at which the regulators turn on when power is first applied. On the +12 volt regulator resistor R106, capacitor C50, and diode D22 control the regulator turn on time. On the +5 volt regulator resistor R73, pot P3 setting, capacitor C48, and diode D21 control the regulator turn on time. Transistor Q27 is turned on to discharge the soft-start capacitors C48 and C50 when the inhibit signal is high. Diodes D21 and D22 isolate the 2 soft-start capacitors from the common discharge path through transistor Q27.

-5 VOLT SERIES PASS REGULATOR

The -5V regulator circuit, as shown in Figure 5A, is a series regulator circuit which utilizes a transistor (Q13) in a series pass mode. Amplifier OA1 senses an error voltage at its inverting input and produces an output voltage sufficient to maintain the output voltage on terminal 1TB-L at -5V. The -5V output is compared with the output from the +5V regulator. When the two voltages are equal in amplitude, the error voltage produced at the wiper of P2 will be near zero volts. A decrease in output voltage produces an error voltage on the wiper of P2. The error amplifier (OA1) changes its output thus increasing the drive to Q13 which in turn causes the output voltage to increase until the error is nearly zero. Transistor Q26 is connected in an emitter follower configuration to increase the drive capability of OA1. Since the -5V regulator uses the output from the +5V regulator as a reference, it will track the +5V supply.

Short circuit protection is accomplished by using transistor Q14 to sense the voltage drop across resistors R54 and R55. When output current increases to approximately 65 ma, transistor Q14 begins to conduct. As transistor Q14 begins to conduct, it pulls the inverting input of OA1 to a negative voltage level, thus causing its output to go positive and turn off transistor Q13.

OVERVOLTAGE PROTECTOR

The overvoltage protector is shown in Figure 5A. This circuit senses overvoltage conditions on the +12V, +5V, and -5V regulated outputs. When any one of these voltages exceed their nominal values by approximately 15%, the SCR1 fires and pulls the VB line toward OV. A fuse must be placed in series with the VB input. This fuse (FU1) is located external to the REG8 board and blows anytime an overvoltage condition occurs.

The three input voltages, +12V, +5V, and -5V are connected to zener diodes BD2, BD3, and BD4. If any of the voltages increase to the point that the zeners conduct, the gate of SCR1 is pulled positive, thus firing the SCR. Once the SCR fires, the external fuse blows. Resistor R102 is placed in the circuit as a convenience during testing. The GVC screw is in place during normal operation of the board.

UNDERVOLTAGE DETECTOR

The undervoltage detector, as shown in Figure 5, senses the +12V, +5V, and -5V regulated output voltages and produces an indication when any one of these voltages is reduced by approximately 5%. The output from this circuit is connected into an input on the power fail detector circuit. The end result of an undervoltage condition is a power fail indication. Operation of the circuit is as follows. Three voltage comparators compare the +12V, +5V, and -5V inputs against a reference voltage derived from the +4.75V source. The comparator inputs are connected such that their inverting inputs will be at the lowest voltage potential during normal operation. Transistor Q5 is used as a clamp diode to prevent comparator input pin 6 from going more negative than -0.5V. The comparator outputs are open collector transistor circuits and are connected in a wired OR configuration. An undervoltage condition on any one of the three inputs causes the output to go to a low voltage of approximately +0.2V.

INPUT POWER MONITOR

The input power monitor is shown in Figure 5. The purpose of this circuit is to detect the loss of AC power. The input is a +18V DC signal that is produced external to the REG8 board and applied to terminal 2TB-A on REG8.

The monitor consists of a voltage comparator circuit that has +4.75 volts connected to its inverting input as a reference voltage. The +18V input is reduced to approximately 6.5V by resistor divider R1 and R2 and applied to pin 9 of the comparator. The comparator's output is connected into an input on the power fail detector circuit. When the +18V input is reduced to approximately +15V the comparator output will go low (approximately +0.2V) indicating an AC power off condition. When the +18V input voltage returns to a normal level, the comparator output will go high (approximately +11V) indicating a power on condition.

BATTERY MONITOR CIRCUIT

The purpose of the battery monitor circuit is to provide an indication when the batteries have been discharged to a voltage level that is insufficient to operate the regulator circuits. The circuit is shown in Figure 5.

The monitor consists of a voltage comparator COMP-1 (output pin 2). The inverting input of the comparator is connected to a +4.75V reference. The battery voltage (VB) is reduced to approximately +7V by the resistor divider (R16 and R18) and applied to pin 5 of the comparator. When the battery voltage drops to +10.2V, the comparator output goes low. When the battery voltage is increased to +10.75V the comparator output goes high. Approximately 0.5V of hysteresis is introduced in the comparator's switching point by feedback resistor R19.

The output of the comparator is connected into the input of the battery down latch formed by the 076-P11 (output pins 11 and 3) CMOS gates. A low voltage on pin 1 of the latch circuit sets the latch. The latch is reset by applying OV to terminal 3TB-E. The outputs from the latch are buffered using CMOS inverters. One inverter drives a transistor circuit that produces the ALLMEMLOSS signal, and the other inverter drives a circuit that produces an INHIBIT signal. The INHIBIT signal is used to turn off all non-essential circuits on REG8 when the batteries become discharged.

POWER FAIL DETECTOR

The Power Fail Detector (as shown in Figure 5) senses several inputs and produces a signal at its output when any one of these inputs are not within specified tolerance. Inputs are provided for sensing the Numerical Control's +5V logic voltage, $\overline{\text{ACOFF}}$ signal, ALLPWRUP signal from the Control magnetics, and an input from the REG8 undervoltage detector. Comparator COMP-1 (output pin 13) compares the inputs at pin 11 with a +4.75V reference which is applied to pin 10. The four inputs are in a diode "AND" configuration such that if any one of these inputs drops to less than +4.75V, the output of COMP-1 (pin 13) goes low. When all of the inputs to the comparator are greater than +4.75V, its output is approximately +11V.

Two CMOS gates and COMP-1 (pin 1) along with the discrete components shown form a debounce and filter circuit. A negative-going pulse on pin 13 of COMP-1 sets the CMOS latch. The circuit parameters are selected such that the latch remains set for a minimum of 2 milliseconds, even if the output of COMP-1 immediately returns to a high level. The minimum pulse width is determined by the rate at which C6 charges and the hysteresis introduced in the switching point of COMP-1 by the 100K feedback resistor.

The CMOS inverter 076-P11 (pin 12) is used as a buffer gate to build up sufficient base drive to transistor Q1. Transistor Q1 is an output driver that produces a logic level signal (PWRFAIL) at terminal 3TB-B. In the event of an undervoltage at the input of the detector circuit, terminal 3TB-B goes to logic 1.

CMOS Supply (Figure 5A)

The CMOS supply is a zener regulated supply that produces an output voltage of +11V when operating from a VB voltage of +12V or greater. When the VB voltage drops below 11V, the zener diode no longer conducts and the CMOS supply voltage also begins to drop; however, the CMOS circuits being supplied will continue to operate until the voltage is less than +3.0V.

VOLTAGE BOOSTER

The voltage booster is shown in Figure 5A. This circuit is a capacitor voltage doubler type of circuit which produces an output voltage (V+) of approximately 1.6 times the magnitude of the input voltage (VB). In addition to boosting the positive voltage, the circuit also provides a negative output voltage (V-).

The circuit consists of an oscillator, power switch, switching diodes, and output capacitors. The oscillator consists of an IC timer package and discrete components. A square wave output voltage at approxi-

mately 5KHz is produced at pin 3 of the timer package. The oscillator frequency is determined by the values of resistors R40, R41, and capacitor C16. The output from the timer drives a power switch which consists of transistors Q8, Q9, Q11, and Q12. These transistors are connected in a Darlington configuration to form 2 Darlington pairs. The collectors of each pair are connected together and to the negative end of capacitor C17 and positive end of C19. Since both transistor pairs have a common input, only one pair turns on during any interval of time. When the input (TS-10) is positive, transistors Q11 and Q12 turn on and Q8 and Q9 turn off. When the input goes positive, capacitor C19 discharges and capacitor Q17 charges through diode D6 to approximately VB. When the input (TS-10) goes low, transistors Q8 and Q9 turn on, and Q11 and Q12 turn off. The negative end of capacitor C17 is pulled up to VB through Q9 and connected to capacitor C18 through D7. This condition effectively places the charged capacitor (C17) in series with VB, therefore the charging voltage which is applied to capacitor C18 through diode D7 is nearly twice the VB voltage.

Transistor and diode drops prevent voltage doubling, but a voltage boost of approximately 60% is obtained as the previous sequence is repeated at the 5KHz rate, returning to capacitor C19 during the time that the input is low and transistors Q8 and Q9 are turned on. Capacitor C19 is charged through transistor Q9 and diode D8 to a voltage approximately equal to VB. When the input (TS-10) goes high, transistors Q11 and Q12 turn on and Q8 and Q9 turn off. This condition connects the positive end of capacitor C19 to OV, thus producing a negative voltage at the junction of D8 and D9. The negative voltage is applied through diode D9 to capacitor C20 causing C20 to be charged to a negative voltage. A negative voltage of approximately 60% of the amplitude of VB is obtained at the V- output as the sequence is repeated at the 5KHz rate.

Transistors Q7 and Q10 limit current flow in the Darlington switches. Transistor Q10 senses current flow in the lower switch by monitoring the voltage drop across resistor R49. When the current through R49 produces a voltage drop across it that exceeds approximately 0.7V, transistor Q10 begins to conduct. As Q10 begins to conduct, it reduces the drive current to Q11 thus preventing Q11 and Q12 current from increasing any further or exceeding approximately 2.6A. Current limiting in the upper switch is similar to that described for the lower switch. Normally the current limit is active only when power is first applied or if a fault occurs which causes the booster to be overloaded.

REFERENCE SUPPLY

The reference supply is shown in Figure 5A. This supply is a series regulated type of supply which uses an IC regulator package. The output is adjusted to +4.75V and used as a reference voltage in all error monitoring circuits.

Transistor Q15 provides an input for placing the regulator in a standby mode when battery voltage is low. When transistor Q15 turns on, (inhibit is high), the output of VR1 goes to zero volts. Turning Q15 off permits VR1 to produce +4.75V at its output.

A potentiometer (P1) is provided for adjusting the output voltage to +4.75V. This adjustment is set in the factory during board test.

ADJUSTMENTS

Voltage Adjustment (Should be made to better than ±2%)
- P1 adjusts reference supply to +4.75V
- P2 adjusts -5V regulated output
- P3 adjusts +5V regulated output
- P4 adjusts +12V regulated output

BATTERY MAINTENANCE

GEL CELL batteries require no maintenance other than a periodic examination of terminal connections.

Battery life is dependent on the number of discharge cycles to which the batteries are subjected. The normal life of the battery is 300 (min) complete discharge cycles. When batteries are only partially discharged a greater number of discharge cycles are obtained.

Testing Batteries

Use the following procedure to test the battery:

1. Insure that the battery is fully charged. Verify this by observing the battery terminal voltage with the battery connected to the PS102 power supply. A voltage of +13.65 volts indicates a full charge. A second method would be to charge the battery from a DC voltage source which is maintained at +14.4 volts while monitoring charging current. When the charging current decreases to 200 ma the battery is fully charged.

2. Place a 12.5 ohm., 25W, resistor across the battery terminal and monitor the terminal voltage. The terminal voltage must be maintained at a voltage greater than 10.2 volts for a minimum of 14 hours.

A second method is to place a 50-amp load on the fully charged battery for 15 seconds. The terminal voltage must remain at 11 volts.

Installation

When connecting batteries into a system, all batteries must be charged to approximately the same capacity.

It is recommended that when it is necessary to replace batteries that all batteries in a system be replaced. An exception would be premature failure of a single battery in a multi-battery system.

When installing a battery with an unknown charge condition, place a 10-ohm, 10-watt, resistor in series with the positive terminal of the battery being added. This 10-ohm resistor will limit current flow until the batteries have obtained approximately equal charges. Remove the resistor after approximately 15 minutes or when equal terminal voltages are observed.

TROUBLESHOOTING

WARNING

Hazardous voltages, currents, and temperatures exist in this supply. Heatsinks may be electrically charged and thermally hot.

Typical voltages and waveforms are shown in Figures 2, 3, 5, 5A and 5B. These measurements would be observed in a properly operating supply when AC power is applied to the PS102 input. Table 4 lists several points that may be monitored and the range of voltages that will be present during normal operation.

TABLE 4

TEST POINT	VOLTAGE (DC VOLTAGE WITH RESPECT TO OV)
PS102, 225TB-C	+15.75 to +17.0V DC
PS102, 222TB-F	+16.0 to +20.0V DC (Approximately 7V Ripple)
PS102, 224TB-A 224TB-B 224TB-C 224TB-D	+12.0V to +14.45V DC +12.0V to +14.45V DC +12.0V to +14.45V DC +12.0V to +14.45V DC
PS102, 222TB-A to 222TB-C	16.2V to 20V AC
PS102, 222TB-A to 222TB-D	16.2V to 20V AC
BCR1 TB-C to TB-A	12.6 to 15.6V AC
BCR1 TB-C to TB-B	12.6 to 15.6V AC
REG8 2TB-A	+16.0 to +20V DC (Approximately 7V Ripple)
REG8 2TB-C	+15.75 to +17.0V DC
REG8 3TB-E	+9.5 to +11.0V DC
REG8 3TB-D	+4.5 to +5.1V DC
REG8 3TB-H	+4.9 to +5.1V DC

(Continued)

TEST POINT	VOLTAGE (DC VOLTAGE WITH RESPECT TO OV)	
REG8 3TB-B 3TB-C	0 to +0.45V DC 0 to +0.45V DC	
REG8 1TB-A 1TB-B	+5.05V DC +5.05V DC	(Adjust P3 - Voltage will be adjusted high to compensate for voltage drops in the wiring between the REG8 and memory boards.)
REG8 1TB-E 1TB-F	+12.01V DC +12.01V DC	(Adjust P4 - Voltage will be adjusted high to compensate for voltage drops in the wiring between the REG8 and memory boards.)
REG8 1TB-L 1TB-M	-5.0V DC -5.0V DC	(Adjust P2.)

If a fault is suspected in the memory power supply, disconnect the memory loads prior to troubleshooting. Table 5 lists symptoms and possible causes for supply problems.

TABLE 5

SYMPTOM	POSSIBLE CAUSE
There is no DC output voltage from REG8 (+12, +5, and -5).	Fuse FU1 is open. Voltage on 2TB-A is out of tolerance. Outputs are overloaded or shorted. There are bad components on the REG8 board.
The system fails to maintain memory when AC power is off.	PWRFAIL signal does not go to +5V when the Control is off. Improper timing sequence of ALLPWRUP and PWRFAIL. See Figure 7. Batteries fail due to aging or not being fully charged. Check adjustments on BCR1. There are bad components on REG8.
Fuse FU1 opens.	Overvoltage condition on REG8. Disconnect memory loads and remove GVC screw on REG8 to troubleshoot.
The memory is not maintained for the specified time.	The battery capacity decreases due to aging. BCR1 is improperly adjusted. There are bad components on the REG8 board.
The voltage at PS102, 225TB-F is less than +16.0V.	There is a preregulator failure. Check D1, D2, Q1, Q2 and BD1 on PS102.
The voltage at PS102, 224TB-A cannot be adjusted to +13.65V with a 120-ohm load between 224TB-A and 224TB-E when the battery is disconnected.	There are bad components on BCR1. Check SCR1 and SCR2.
PWRFAIL on REG8 3TB-C stays high or pulsing.	VPS input at REG8 2TB-A too low or not filtered properly. Check D5, D6 and C2 on PS102.

RENEWAL PARTS

Renewal parts for the 3N8100PS102 power supply are given below:

Description of Part	Catalog Number	Quantity Used
Transformer (T1)	44B398058-001	1
Inductor (L1)	44B314126-001	1
Printed Circuit board (REG8)	44A399746-G01	1
Printed Circuit board (BCR1)	44A399708-G01	1
Capacitor - 12000 mfd, 30V (C1)	44A390238-N12	1
Capacitor - 10 mfd, 25V (C2)	44B310008-K10	1
Capacitor - 100 mfd, 25V (C3)	44B310008-L10	1
Resistor - 0.1 ohm, 5W (R1, R2, R3, R4)	128A4061B10	4
Resistor - 1.0 ohm, 20W (R5)	K8622213C10	1
Resistor - 330 ohm, 1W (R6)	259A9011P331	1
RC Network (RC4)	44B233199-001	1
Rectifier (D1, D2, D3)	1N1342A	3
Rectifier (D4)	1N1186A	1
Rectifier (D5, D6)	44B232019-004	2
Silicon Control Rectifier (SCR1, SCR2)	44B212741-005	2
Zener - 18V, 1W, 5% (BD1)	1N3026B	1
Transistor (Q1)	44B238208-001	1
Transistor (Q2)	44B390244-001	1
Transistor Socket for Q1	44A397962-002	1
Transistor Socket for Q2	44A397962-001	1
Insulating washer for D1, D2, D3	44A395907-011	3
Solder Lug for D1, D2, D3	44A395908-005	3
Washer for D1, D2, D3	44A399623-009	3
Insulating washer for D4, SCR1, SCR2	44A395907-013	3
Solder Lug for D4, SCR1, SCR2	44A395908-002	3
Washer for D4, SCR1, SCR2	44A399623-011	3
Insulator for Q1	44A395907-003	1
Insulator for Q2	44A395907-002	1
Insulator for D1, D2, D3	44A393674-009	3
Fuse - 2 amp, 250V (FU1)	K9774740P105	1
Fuse - 20 amp, 250V (FU2)	K9774700P6	1
Fuse - 10 amps, 250V (FU3)	K9774717P2	1
Fuse Block for FU	44A399626-001	1
Fuse Block for FU2	44A399624-001	
Toggle Switch (SW1)	44A395936-001	1
Bracket for SW1	44B293233-010	1
Terminal Board (221TB, 223TB, 224TB, 225TB)	44B211501-105	4
Terminal Block (222TB)	K9189496G1	1
Strip for 222TB	K9108801P5	1
Insulators for mounting BCR1 and REG8	44B230672-G06	14

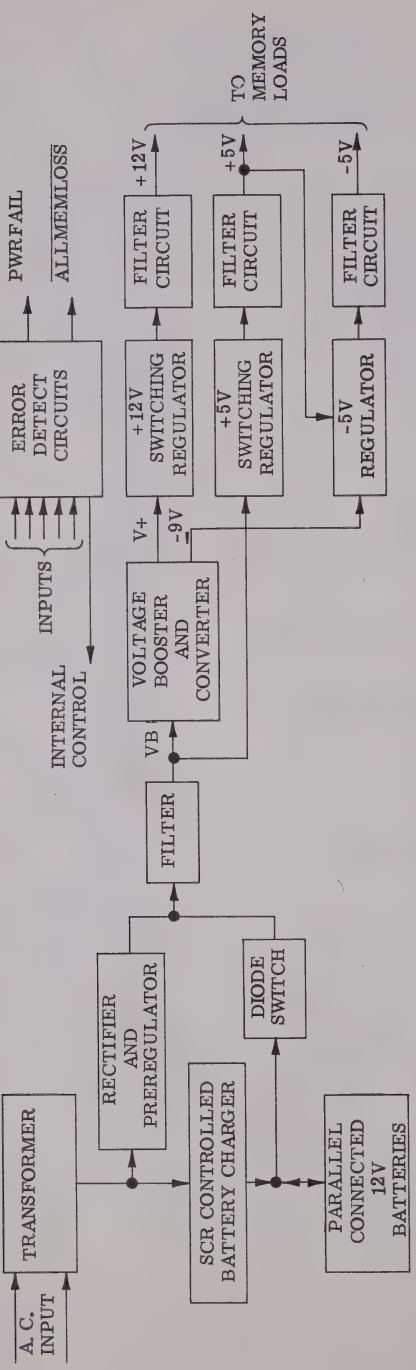


Figure 1.
BLOCK DIAGRAM OF MEMORY POWER SUPPLY

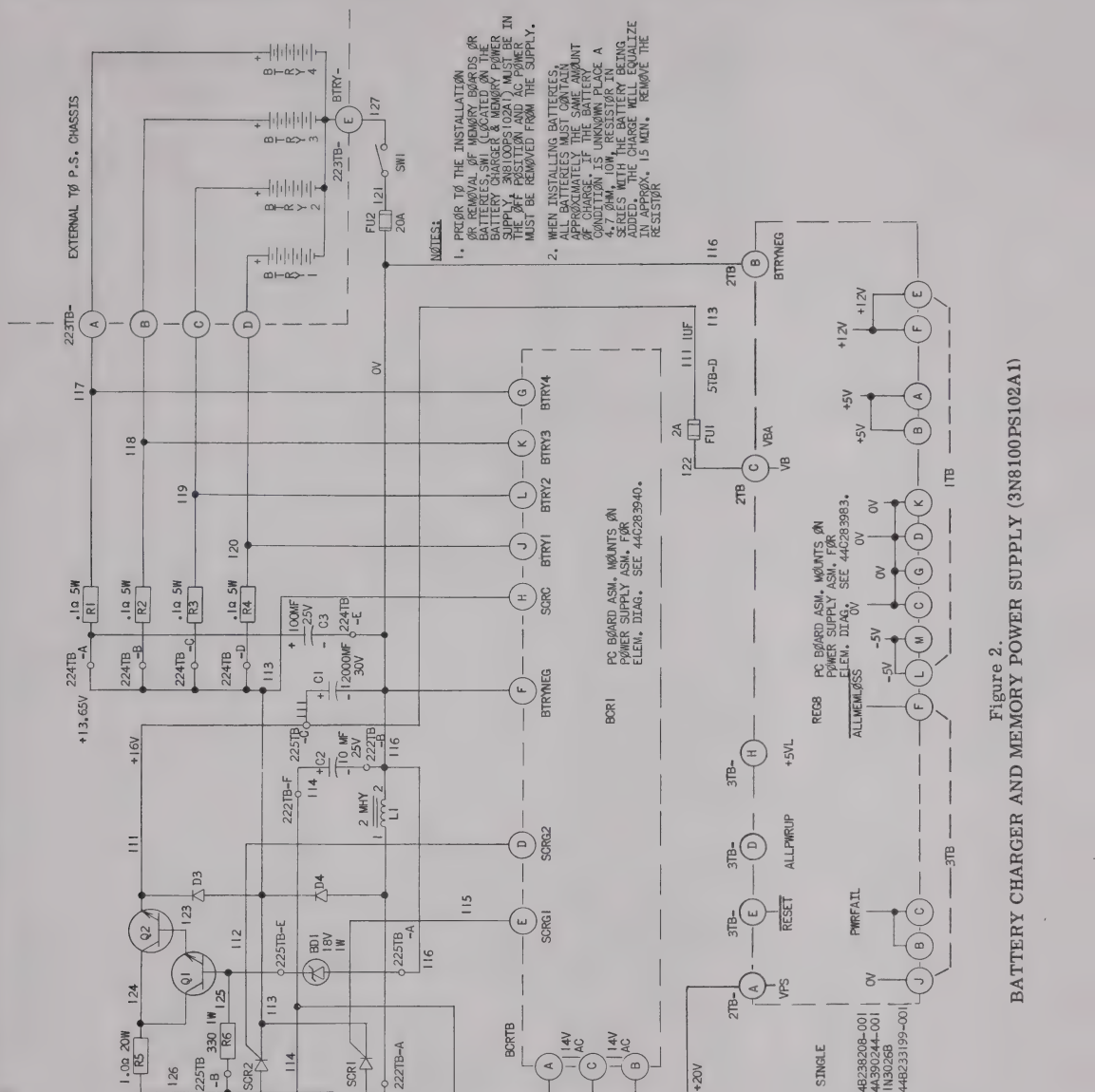


Figure 2.
BATTERY CHARGER AND MEMORY POWER SUPPLY (3N8100PS102A1)

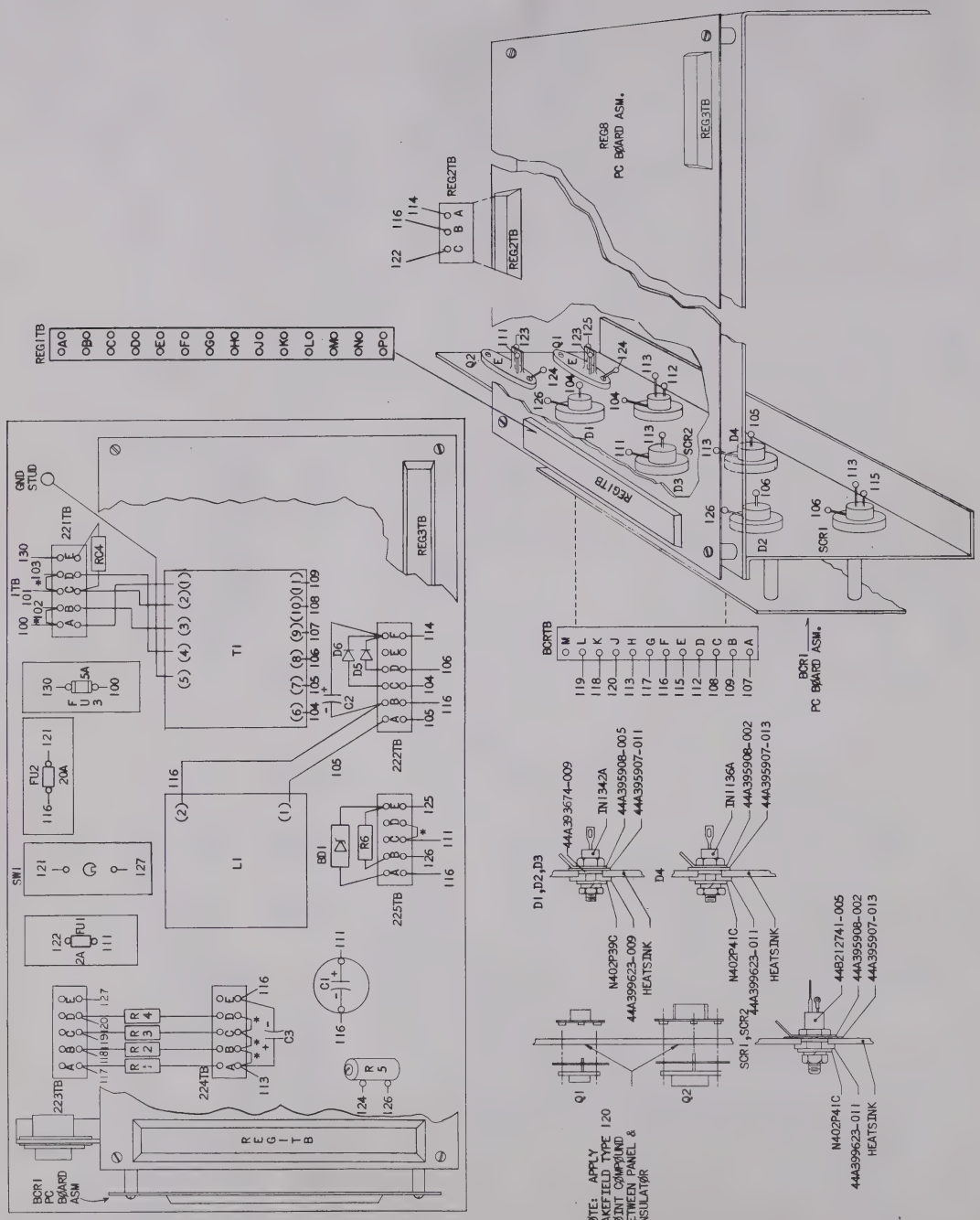


Figure 2A.
BATTERY CHARGER AND MEMORY POWER SUPPLY
(3N8100PS102A1)

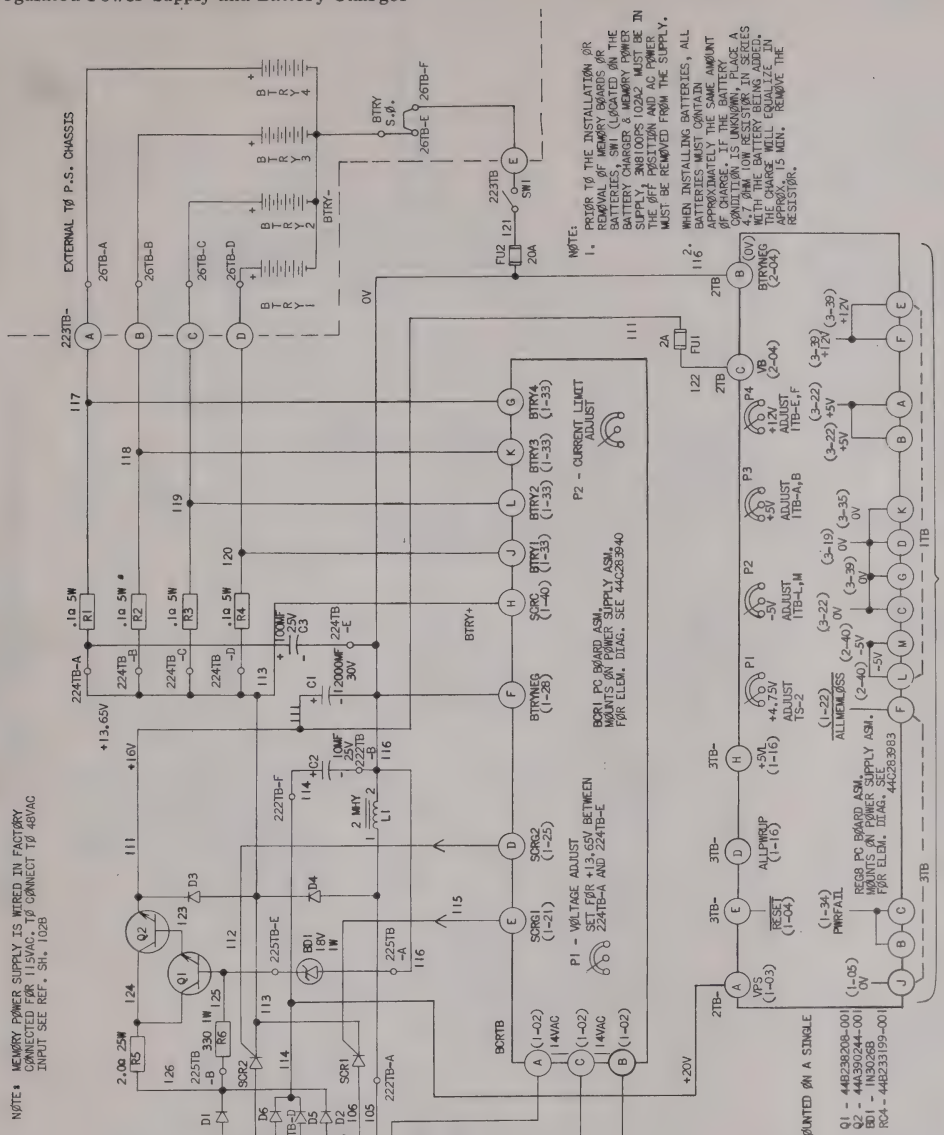


Figure 2B.
BATTERY CHARGER AND MEMORY POWER SUPPLY
(3N8100PS102A2)

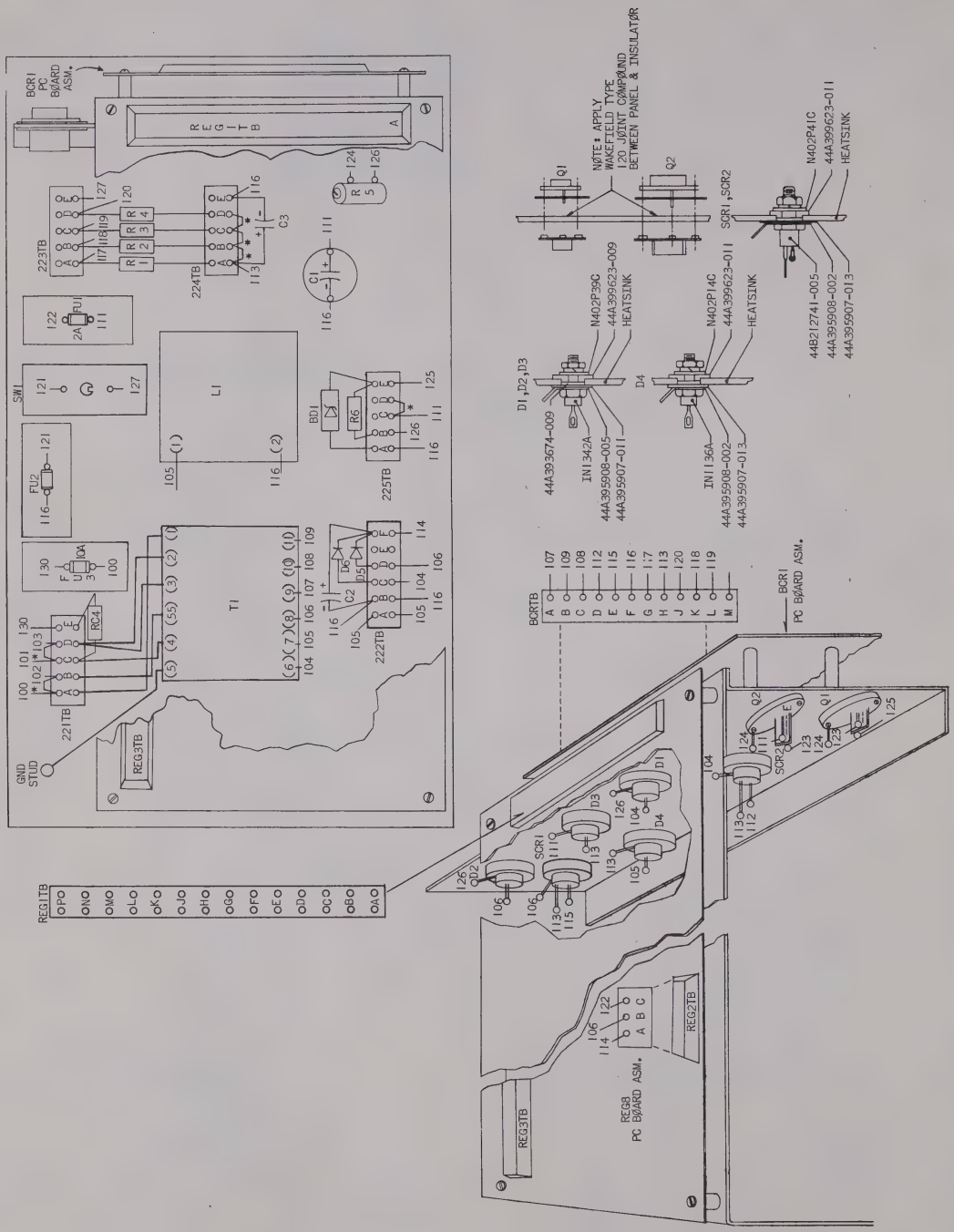


Figure 2C.
BATTERY CHARGER AND MEMORY POWER SUPPLY
(3N8100PS102A2)

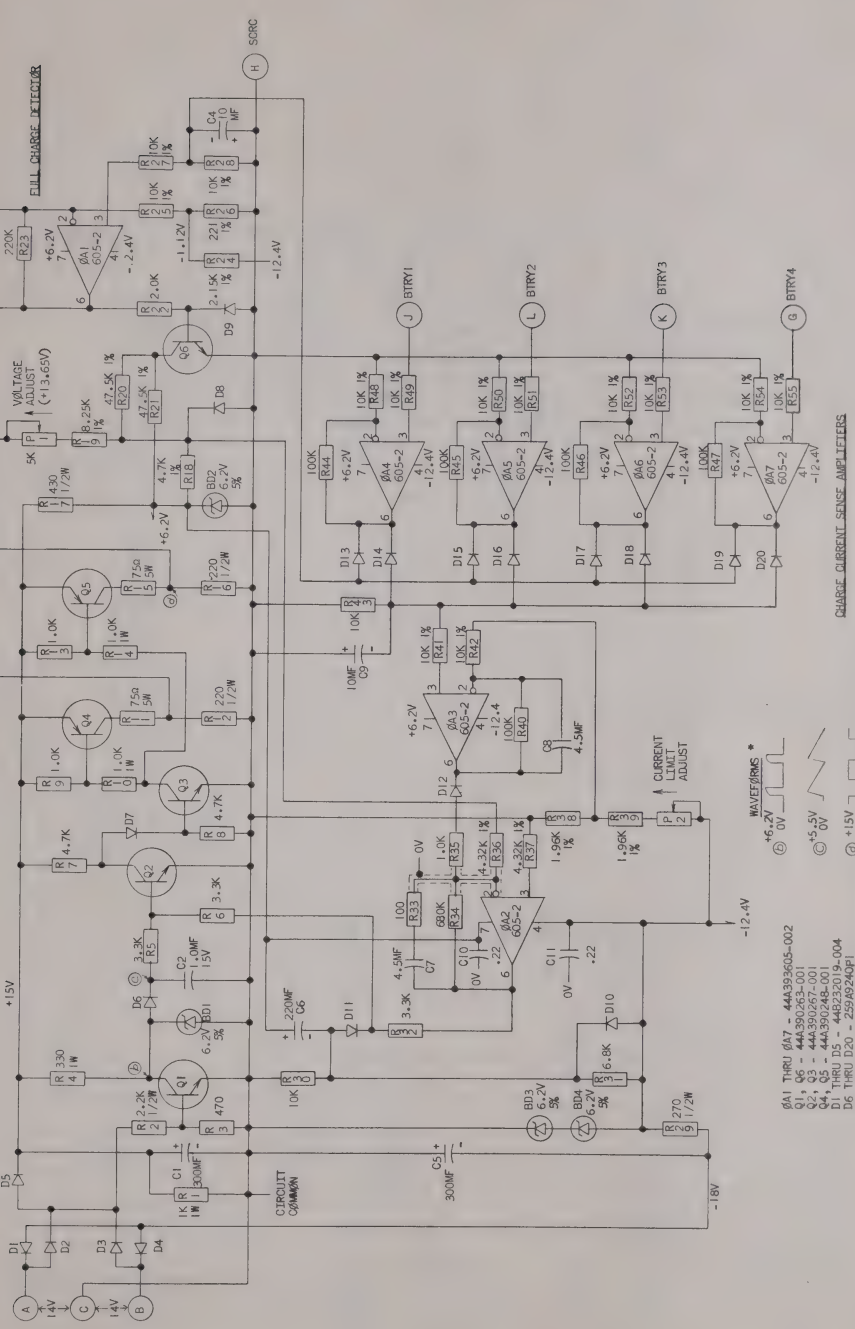


Figure 3.
BCR1 PRINTED-CIRCUIT BOARD

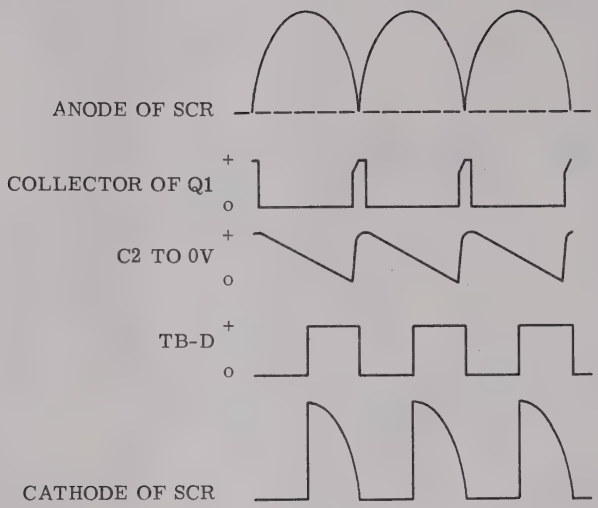


Figure 4.
BCR1 WAVEFORMS

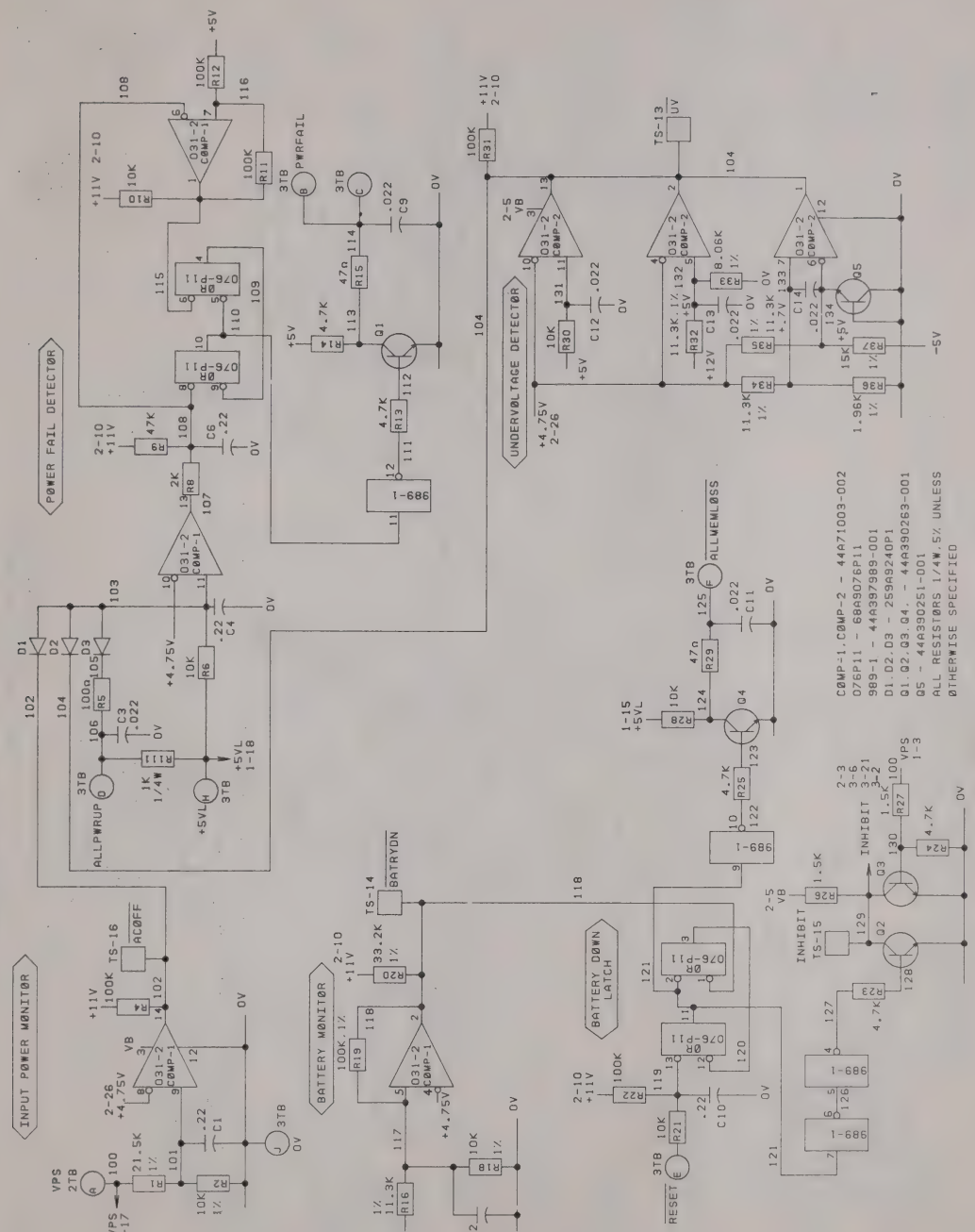


Figure 5.
REG8 REGULATOR BOARD
(Continued on 5A)

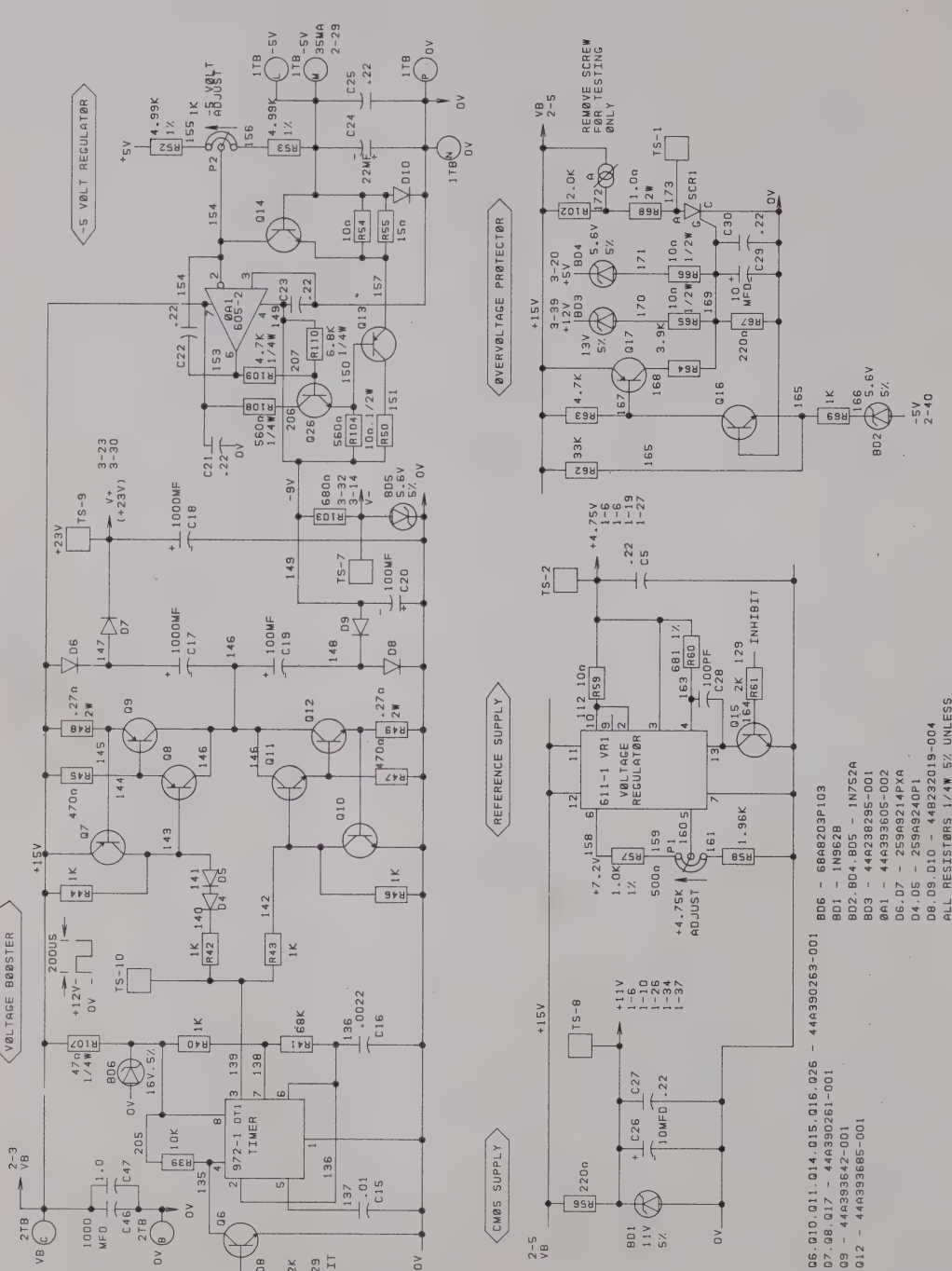
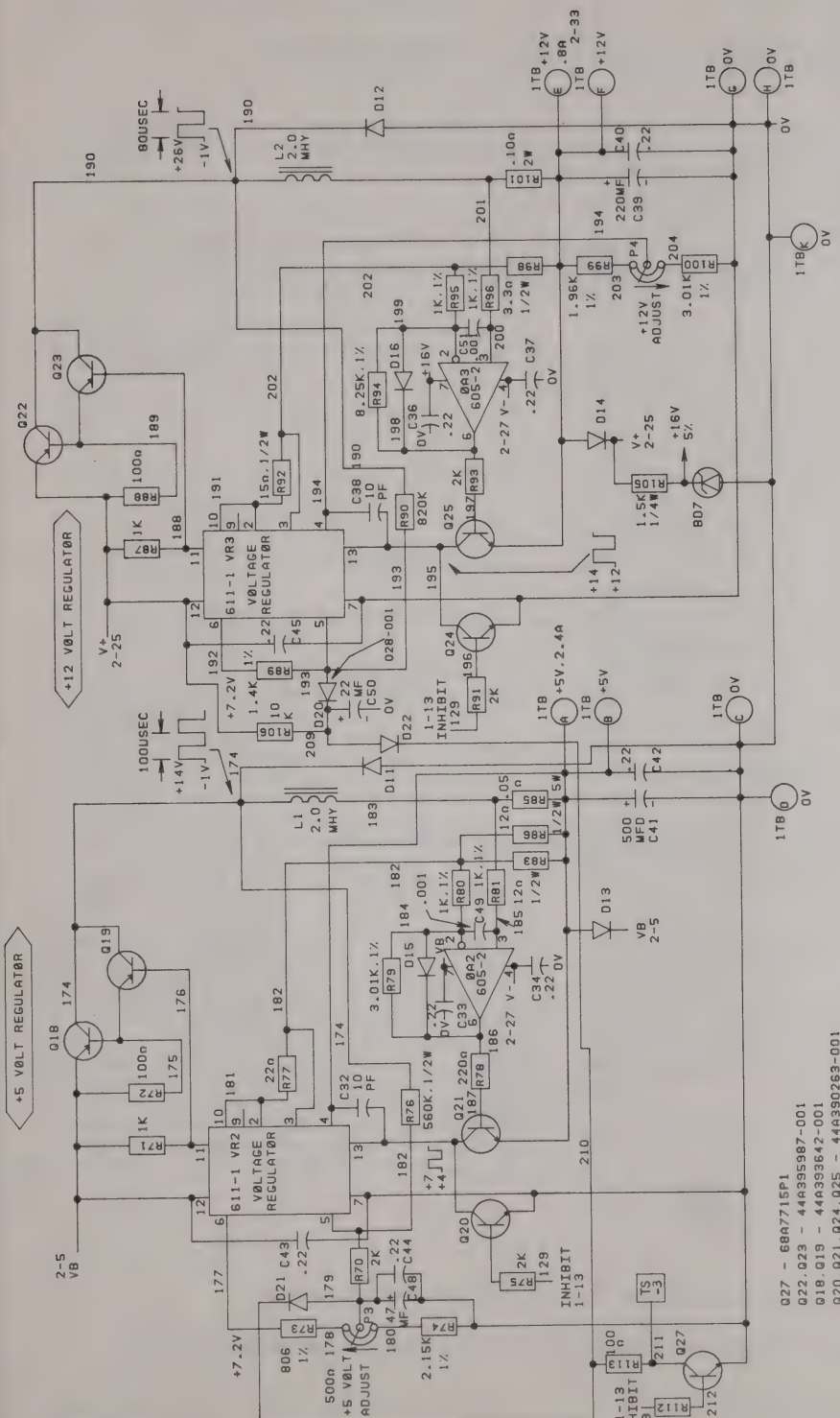


Figure 5A.
REG8 REGULATOR BOARD
(Continued on 5B)



Q27 - 68A7715P1
Q22.Q23 - 44A395987-001
Q18.Q19 - 44A393642-001
Q20.Q21.Q24.Q25 - 44A390263-001
D11.D12 - 2594A9214PXA
D13.D14 - 44B232019-004
D15.D16.D20.D21.D22 - 2594A9240P1
0A2.0A3 - 44A393605-002
L1.L2 - 44B398010-001
VOLTAGES AND WAVEFORMS SHOWN ARE TYPICAL

ALL RESISTORS 1/4W 5% UNLESS OTHERWISE SPECIFIED

Figure 5B.
REG8 REGULATOR BOARD

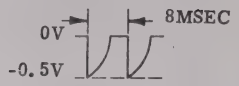


Figure 6.
VOLTAGE WAVEFORM FROM 224TBA TO 223TB-A

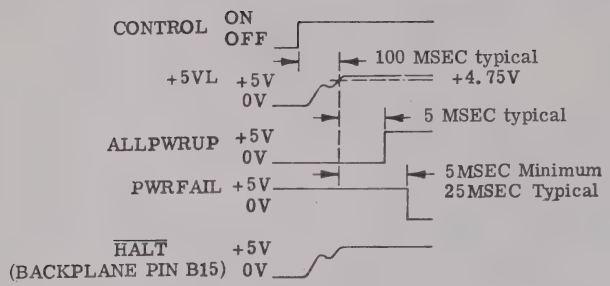


Figure 7A.
VOLTAGE WAVEFORMS DURING CONTROL ON SEQUENCE

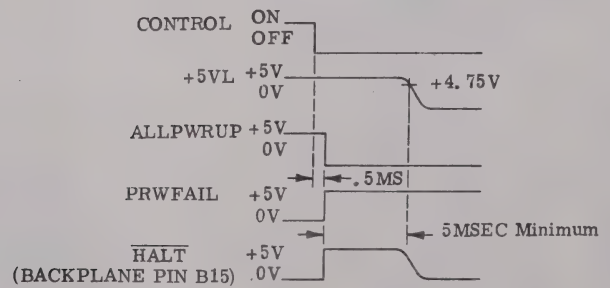


Figure 7B.
VOLTAGE WAVEFORMS DURING CONTROL OFF SEQUENCE

POWER SUPPLY SERIES 3N8100PS103A1

The power supply converts power from 50/60 Hz, 120 VAC +10%, -15% floating input to the following 3 DC buses:

+5 VDC, ±1%, 45 ADC

+12 VDC, ±2%, 8 ADC

-12 VDC, ±2%, 3 ADC

The voltages on ±12V buses track each other within 0.2 volts. The buses maintain regulation in the range of 15% to 100% of rated load.

The power supply is switched off for the following faults:

+5V, ±12V bus undervoltage and overvoltage

+5V, ±12V bus overcurrent

+5V, ±12V bus unbalance of transformer primary current

Power supply auxiliary bus (±15V) undervoltage and overvoltage

With the exception of a few components, the entire power supply is mounted on 3 printed-circuit boards. The REG9 board contains the power supply control circuits, +15 VDC and -15 VDC auxiliary power supplies as well as the regulator circuits for all 3 buses; the PS112 contains the power output stages for the ±12V buses; the PS105 board contains the power output stage for the +5V bus, except for the output filter inductor, which is mounted on the chassis.

The functiona.. diagram for the power supply is shown in Figure 1. The elementary is shown in Figure 2.

Pulse-width modulation to implement voltage regulation is used. The incoming AC power is rectified and filtered in order to produce a 108 VDC unregulated bus. The power switching transistors at the primary of a bus output transformer are switched on alternately. Since the 108V bus is connected to the center-tap of the transformer, the transistor switching action produces a train of bi-directional pulses in the transformer primary. These pulses are transformed to a lower voltage in the secondary, and are rectified and filtered in order to produce direct current at the bus output.

The bus output voltage is compared with preset reference voltage, and the difference or error is amplified by error amplifier. The output of this amplifier is in turn compared with a triangular voltage waveform from the integrator. The comparison is performed by a voltage comparator (VC) whose output is a pulse train. The width of the individual pulses is proportional to the error signal. The pulses are amplified and are then used to drive the power switching transistors.

The switching operations in all 3 buses are synchronized by the oscillator, which has an output frequency of 20 KHz. The oscillator drives the integrator, which in turn produces a 10 KHz triangular wave which is used in pulse-width modulation. The pulses from the oscillator also trigger a flip-flop which produces a 10 KHz square wave used for channeling the control pulses alternately to each half of the output transformer primary.

INPUT POWER RECTIFIERS AND FILTER

The 120 VAC input is rectified in a bridge circuit and is then fed to a LC filter. The filter reduces the line frequency ripple, as well as providing an energy storage to enable normal operation during low-voltage transients on the incoming line.

REG9 PRINTED CIRCUIT BOARD (Figure 3A through 3F)

The REG9 board contains the voltage regulating circuits for ±12 VDC buses on the PS112 board and for +5 VDC bus on the PS105 board. Also included are the power on/off control and overvoltage and undervoltage detection circuits. The circuits use +15 VDC and -15 VDC auxiliary buses which are generated on the REG9 board.

±15 VDC Auxiliary Power Supply (Figure 3F)

The input power for +15 VDC bus is derived from 25 VDC, which is supplied by the N.C. control. The +15V supply is zener-regulated. Besides providing +15V output, it also generates BUS AB, which is used on PS112 and PS105 and has a nominal value of 13 VDC.

The -15 VDC is also zener regulated and derives its input power from a 38 VAC centertapped transformer winding.

Both power supplies are monitored for overvoltage and undervoltage. In the case either condition is detected, the main power supply buses (+5 VDC, ±12 VDC) are inhibited. However, no action is taken in the ±15 VDC auxiliary supply.

When the Control is started with the 25 VDC absent in the power supply, +15 VDC bus cannot be generated and neither can its absence be detected by +15V undervoltage circuits. In such a case, DC1, which is generated in the main power supply input circuit, provides power to the +15V undervoltage circuit, which in turn prevents the main power supply from being switched on.

Power On/OFF Control (Figure 3D and 3E)

In order to initiate the power-on sequence, an N.C. relay contact (IPO, Figure 3D), which is supplied by the Control, must be kept open until all three of the buses come up to their nominal value. This is accomplished by the signal from the IPO circuit being able to override the bus undervoltage signal in the OR gate at Q11.

In the Soft Start Circuit (Figure 3E), transistor Q20 is kept switched on before the regulator start up sequence is initiated. Q20 keeps the 300 μf capacitor in the voltage reference bus (VRB, Figure 3C) discharged until it is switched off by opening the IPO contacts in its collector. The 300 μf capacitor then charges slowly, thereby controlling the rise time of reference voltage to error amplifiers of all buses. Transistor Q22 keeps transistor Q20 in a switched-off condition after the startup sequence is completed as long as the power supply stays switched on.

The ALL PWR UP signal output and relay puller for COR circuits (Figure 3E) provide signals to the Numerical Control in order to facilitate an orderly power-on, power-off sequence.

The power supply is switched off by disrupting the AC input to the power supply. Subsequently the voltage of the output buses diminishes and the undervoltage detection circuit inhibits the drive pulse generation, thereby switching off the power supply output circuits on PS112 and PS105.

Oscillator (Figure 3A)

The oscillator circuit supplies 20 KHz pulses, which are used in the pulse-width modulating circuit of the regulator for each of the 3 buses. In the oscillator, the zener-produced reference voltage is compared with the output of OA2. Each time the latter exceeds the reference voltage, the voltage comparator VC3 changes state. In the process, the voltage comparator produces a square wave which is symmetrical about the zero volt level and whose frequency is determined by the RC-circuit of the integrator (OA1). The integrator output is a triangular pulse train (Figure 6D).

Error Amplifier-Pulse Width Modulation (PWM)

This part of the circuit is separate for each of the 3 buses. Although the error amplifier and PWM circuit is similar in principle for each of the buses, it differs in detail. The circuit for +12VDC bus is described fully (Figure 3C) and then the differences between it and the -12VDC and +5VDC bus error amplifier and PWM circuits are explained.

The operational amplifier 1/4 OA5 (input pins 5 and 6, output pin 4) forms the error amplifier in the +12 VDC circuit. The input +12F is obtained from PS112 board +12VDC bus, and is reduced to 5.1V by the zener diode at the amplifier input resistance. It is compared with the reference voltage from the +12V Adjust potentiometer which is preset to give +12 VDC at the +12V bus on the PS112 board. The error amplifier takes the difference between the actual bus voltage and the reference voltage and produces a DC voltage at the amplifier output which is proportional to the difference and which can be positive or negative, depending on the polarity of the error. The DC voltage thusly produced is compared in the following voltage comparator with the triangular wave from the integrator (INT OUT).

Since the voltage comparator is a very high-gain device, its output is positive when the voltage of the triangular wave falls below the voltage of the error amplifier output (Figures 6K and E). Since the latter varies with the error of the +12 VDC bus, a pulse width proportional to the error is produced at the output of the voltage comparator. The output NAND gate, in conjunction with signals Q and $\overline{Q}$ produces 2 pulse trains of 10 KHz each, with the pulse in the 2 trains being 180° apart (Figures 6F and G).

The purpose of the zener diode at the output of the error amplifier is to limit the amplifier output so that the pulse intervals of the voltage comparator output are not less than approximately 8 microseconds. This measure prevents power output transistor cross-fire on PS112.

The -12 VDC bus error amplifier and PWM circuit is similar to +12V circuit but with 2 essential differences: First, the +12 volt bus is used as the reference voltage to error amplifier. This, in essence, causes the -12V bus to follow the +12V bus closely. Secondly, due to the fact that -12V is a negative voltage, the polarities of the voltages at the input of voltage comparator are different (Figures 6H through 6L).

The +5VDC bus amplifier and PWM circuit (Figure 3A and 3B) is identical to the +12V circuit, except that a circuit to balance the pulse current in the primary of the output transformer of the +5 VDC bus on the PS105 board has been added.

The input signal to each channel of the balance circuit (signals CS51 and CS52 in Figure 3B) is obtained from the emitter resistance of the corresponding power switching transistor on the PS105 board. Each input is compared with voltage from the Balance Adjust potentiometer which is pre-adjusted for optimum balance of the bi-directional current pulses in the primary of the output transformer on the PS105 board. Thus the first stage in each channel produces a voltage level which is proportional to the deviation of the transformer primary current from the balanced condition. In the next stage, by means of a resistance network which interconnects both channels, a differential signal is formed which is equal in magnitude but opposite in polarity from the 2 channels. The amplified equal but opposite signal is added to the output of the error amplifier before it is fed to the voltage comparator for each channel. The signals from the balance circuit modify the pulse width so as to bring the bi-directional current pulses in the primary of the output transformer closer to the desired balance.

Bus Overcurrent Detector

The overcurrent detector circuits are identical for all 3 buses (Figure 3A for +5V bus; Figure 3C for ±12V buses). In each case, the input to the detector circuit is formed by the voltage across the resistor which is connected in series with the bus load on the power output board (PS105 and PS112). The voltage is amplified by a differential amplifier and then compared to a reference (+5V) by a voltage comparator. The voltage comparator normally has a positive voltage output and is by means of diodes, essentially isolated. If the load overcurrent condition exists, the voltage comparator output goes negative. Consequently, the reference voltage to the error amplifier will become such as to cause the bus to generate an abnormally low bus voltage. Also, the Overvoltage Latch flip-flop sets. These actions cause the drive signals to the power output stages to be inhibited and when the power supply is properly connected to its magnetics, the power supply is taken off the power input line until the normal startup sequence is initiated.

Transformer Primary Fault Sensor (Figure 3E)

The voltage across both emitter resistance in the power switching output stage (on PS112 or PS105) is fed to an OR gate on REG9 board. If the volt-second figure at any one of the six OR-gate inputs exceeds a pre-determined value (approximately 5.5 volt-microsecond), indicating excessive current in the primary winding of the power output transformer, the OR gate is driven to logic 0. This sets the Overvoltage Latch flip-flop.

Bus Overvoltage and Undervoltage Detection

The +5V and the -12V bus overvoltage and undervoltage are monitored. If either of these bus voltage values go out of the permitted band of operation, the drive signals to power output stages are inhibited. In the case of undervoltage, the bus voltages are automatically restored if the undervoltage condition is momentary (less than pickup time for the relay connected to Relay Puller for COR relay). For overvoltage condition, the drive signals are inhibited by the Overvoltage Latch flip-flop being set. The power supply is activated until the normal start up sequence is initiated.

Since -12V is made to follow the +12V bus, the -12V undervoltage and overvoltage circuit also automatically monitor the +12V bus.

PS112 PRINTED-CIRCUIT BOARD (FIGURE 4A AND 4B)

The PS112 board contains the power output circuitry for the +12V bus (capacity 8ADC) and -12V bus (capacity 3ADC). Since the operation of the circuit for both buses is similar, only the +12V circuit is described below.

The low signal level part of the circuit is powered by BUS AB (nominally 13 VDC) which is generated on the REG9 board. Each input ($\overline{P121}$ and $\overline{P122}$) receives an identical 10 KHz pulse train, except that pulses alternate; i.e., the 2 pulse trains have a phase shift of 180° with regard to each other. The pulse is considered active when it is at or near OV level (approximately +1V). The pulse is considered inactive when it is approximately +14V. The active pulses can never overlap. After the pulse at one input has terminated, an 8-microsecond interval is generated by the REG9 board before the pulse at the other input terminal is permitted to start.

When the pulse at $\overline{P121}$ is at the inactive state (positive voltage), transistors Q3 and Q4 are kept on, thereby keeping the Darlington-connected power transistors Q5 and Q6 off. When the input pulse becomes active (zero voltage), transistors Q3 and Q4 switch off and Q2 switches on. Q2 in turn switches on the output Darlington pair (Q5, Q6). Since a DC voltage of approximately 108V is connected to the transformer primary centertap, a pulse of this magnitude appears across one half of the primary of the transformer.

When Q2 switches on, it also charges the capacitor C2 to approximately 8V. When Q4 switches on, this voltage is applied across the base-emitter junctions of Q5 and Q6 and is instrumental in turning these transistors off fast.

Since each half of the circuit is switched on alternately, a pulse train with positive-going and negative-going pulses appears across the transformer primary. This pulse train is transformed to a lower voltage in the secondary winding and is subsequently rectified, filtered and appears as +12 VDC at the output terminal of the board. The wave forms for PS112 are shown on Figure 7.

Q1 and Q8 and components associated with these transistors form a crossfire prevention circuit if the storage time of either Q6 or Q12 exceeds 8 microseconds.

Diodes D5 and D12 form a circulating path for the current which is created by the voltage induced in the transformer primary when the flux collapses due to a rapidly terminated pulse. The same function is also performed by the snubber circuit across the transformer primary (C14, C15, and R19).

The REG9 board monitors the voltage drop across the resistors in the emitter circuit of Q6 and Q12 for excessive current in either half of the transformer primary due to the unbalance in the transformer.

The REG9 board also monitors the voltage drop across the resistors in series with the bus output (R21, R22, R23) for overcurrent due to low or zero load impedance.

PS105 Printed-Circuit Board (Figure 5)

The PS105 board contains all the power circuitry for the +5VDC bus with the exception of the output filter inductor which is mounted on the chassis.

The operation of the circuit on PS105 board is the same as for the +12V bus power output circuit on PS112. The wave forms for PS105 board are shown in Figure 7.

PREVENTIVE MAINTENANCE

WARNING

Hazardous voltages, currents, and temperatures exist in this supply. Heatsinks may be electrically charged and thermally hot.

Because of the use of solid state components in this power supply, preventive maintenance measures are not necessary except for periodic measurements of output voltages. The output voltages should be measured at the power supply and at the point of application, in order to ensure that all connections are secure and that high-resistance paths have not been formed. The output voltages should be within tolerances given on page 5 of this instruction.

POWER SUPPLY PROTECTION

AUTOMATIC SWITCHOFF

The power supply is automatically switched off for the following fault conditions:

+5V, ±12V bus undervoltage and overvoltage

+5V, ±12V bus overcurrent

+5V, ±12V bus unbalance of output transformer primary current

Auxiliary bus (±15 VDC) undervoltage or overvoltage

FUSES

Fuses are used in the power supply as a backup measure in order to disconnect a faulty circuit. Information on fuses is given in the outline shown below.

Fuse Designation and Location	G.E. Part No.	Equivalent Vendor No.
Input fuse, 1FU, 6A On chassis	K9774700P3	Chase Shamut One-Time
-15 VDC bus fuse, 1/4A On REG9 board	K9774740P2	Littlefuse 312 250 Bus AGC 1/4
+12 VDC bus fuse 3FU, 3A On chassis	K9774740P3	Littlefuse 312003 Bus AGC3
-12 VDC bus fuse, 4FU, 2A On chassis	K9774740P5	Littlefuse 312002 Bus AGC2
+5 VDC bus fuse, 2FU, 5A On chassis	K9774740P10	Littlefuse 312005 Bus MTH5

ADJUSTMENTS

BUS READJUSTMENT

All buses have been adjusted in the factory during the final test. Normally it is not necessary to readjust the voltage value of the buses. However, should this need arise, the buses can be adjusted by connecting a voltmeter with 0.1% accuracy to the bus to be readjusted. A bus should be readjusted when it is driving approximately its normal load in the system. The adjustment of a bus should be made to a value as close as possible to the nominal bus value at the point of usage (logic rack). The information needed for the bus readjustment is given below.

Nominal Bus Voltage	Permitted Overall Bus Tolerance	Potentiometer Location on REG9 Board
+5 VDC	±1%	P1
+12 VDC	±2%	P4
-12 VDC	±2%	P5
	Within 0.2V of +12V Bus	

+5V BUS TRANSFORMER PRIMARY BALANCE ADJUSTMENT

The balance adjustment needs to be made only if either the PS105 board or REG9 board is replaced. A dual-trace oscilloscope is necessary for the adjustment. On the REG9 board connect the probe of the oscilloscope to test point 4PL-1, and the other probe to 5PL-12. Connect the oscilloscope ground to test point 5PL-11 on the REG9 board.

Turn the Control on. The waveforms should be as shown in Figure 7 (E and F). The peaks of 2 trains of pulses (marked P, Figure 7, should be within 0.030 volts of each other. If they are not, carefully adjust potentiometer P2 on REG9 board for the difference in peak voltages of no greater than 0.030 volts.

Note: Take care when adjusting P2 so that an excessive current unbalance will not occur in the transformer primary. This unbalance constitutes a fault, which can trip the power supply.

TROUBLESHOOTING

WARNING

Hazardous voltages, currents, and temperatures exist in this supply. Heatsinks may be electrically charged and thermally hot.

The power supply is automatically switched off for the following faults:

1. Load fault condition
   Overvoltage
   Undervoltage
   Overcurrent
2. Blown fuse
3. Line voltage power outage (minimum two cycles of 60Hz power)
4. Component failure

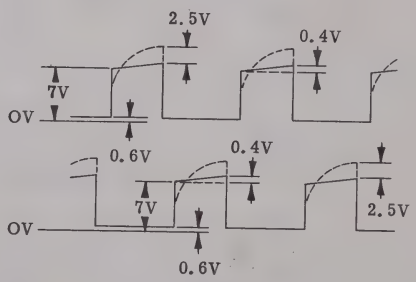
The failure of a component can manifest itself as an apparent fault. Unless the fault clears itself, as for instance a momentary short circuit of load, or a short-duration power outage, the power supply will not come on again when the Power On pushbutton is depressed. If the power will not come on, look for a loose terminal, broken wire or bus terminals touching each other or ground either in the power supply or in the Numerical Control. Troubleshooting as outlined below can only be successful after all external faults are corrected.

SWITCHING TRANSISTOR CHECK

1. Remove fuses 2FU, 3FU, 4FU. If one or more fuses are blown, the bus with the blown fuse is suspect and should be investigated first.

2. In order to check a bus, connect dual oscilloscope probes alternately to test points indicated in the following table. When the Control on pushbutton is not depressed, all test points should read approximately 0.2 VDC.

3. When the pushbutton is being depressed, wave forms as shown with solid lines (below) should appear. If the wave form is absent or distorted, particularly as shown with the dotted line, replace the board under test.



NOTE: 1. ALL VOLTAGE VALUES ARE APPROXIMATE AND ARE FOR REFERENCE ONLY.
2. THE WAVEFORMS ARE NOT TO SCALE.

Bus	Test Points	Oscilloscope Ground
+5V (PS105 board)	22PL-4 22PL-5	22PL-2
+12V (PS112 board)	12PL-2 12PL-3	12PL-5
+12V (PS112 board)	13PL-3 13PL-4	13PL-5

REG9 BOARD CHECK

1. When measuring voltages on the REG9 board, place the oscilloscope or voltmeter ground on 5PL-11 or 4PL-8.

2. Measure the following voltages on the REG9 board. If the voltages are not as specified, replace the REG9 board.

NAME	LOCATION ON ELEMENTARIES	TEST POINT ON REG9	VOLTAGE (VDC)
+15VDC Aux. Bus	Figure 3F	6PL-6	15.7 ± 1.0
BUS AB	Figure 3F	1PL-10	13.7 ± 1.0
-15VDC Aux. Bus	Figure 3F	6PL-3	15.2 ± 1.0

3. Check the wave forms as indicated. If they are absent, distorted or if the distance between pulses is less than 7 microseconds, replace the REG9 board. These wave forms are measured with the Control On pushbutton depressed.

REFERENCE	TEST POINT ON REG9
Figure 7E	5PL-3 5PL-7 4PL-2
Figure 6E	4PL-6

4. Measure voltages as indicated in the outline on the following page. If the voltages are not as specified, replace the REG9 board. Logic 1, where specified, should measure approximately 14 VDC. Logic 0 should measure approximately 1VDC.

SIGNAL NAME	LOCATION ON ELEMENTARIES SEE FIGURE	TEST POINT ON REG9	REQUIRED LOGIC SIGNAL
+5V Bus O/C Sense	3A	5PL-4	L1
+12V Bus O/C Sense	3C	4PL-3	L1
-12V Bus O/C Sense	3C	4PL-5	L1
Bus U/V - O/V Sense	3D	4PL-7	L0
Bus O/V Sense	3D	4PL-9	L1
Initiate P.S.	3D	4PL-4	L0
Transformer primary fault Sensor	3E	6PL-4	L1
Current ref. bus	3C	6PL-9	5VDC ±0.2V
± 15V Bus Sense	3F	6PL-1 6PL-5	Approx. 24VDC
Voltage ref. bus	3C	5PL-14	L0
Voltage ref. bus with Control On pushbutton depressed	3C	5PL-14	6.7VDC + 0.5V

POWER INPUT CIRCUIT CHECK

1. If a fault was found and fixed, insert 2FU, 3FU, and 4FU. Switch the Control on by depressing the Control On pushbutton.

2. If the power supply does not stay on, disconnect AC power from the Control. Disconnect all normal loads from the power supply buses. Connect separate loads to each of the buses for 20% -- 30% of bus rated capacity.

3. If the power supply now stays on, the problem was load-oriented: overload or a short circuit on any one of the 3 buses.

4. If the power supply does not stay on with the auxiliary loads, check the AC power input and the DC link (items 5 and 6 below), and then check each bus individually ("Bus Output Circuit Check").

5. Alternately connect the digital voltmeter to the following points. Make sure that the probe does not short to adjacent terminals or components as voltages up to 150 VD will be measured.

	VOLTMETER	COMMON
On PS405 Board	DC1	PSG1
On PS112 Board	DC2	PSG2
	DC3	PSG3

6. Push the Control On pushbutton. Although the buses may not latch in, the voltmeter should read a DC voltage in the range of 110VDC to 150VDC as long as the pushbutton is activated. If the DC voltage is absent or appreciably smaller, investigate relay IPOA and the DC link (1FU, DB1, L1, C1), as well as the wiring associated with these components. Also check the bus fuses (2FU for +5V bus, 3FU for +12 bus and 4FU for -12V bus).

BUS OUTPUT CIRCUIT CHECK

1. Check the 5V-bus on PS105 by leaving 2FU in place and removing 3FU and 4FU. Proceed with steps 4 through 17.

2. Check the +12V bus separately by leaving 3FU in place and removing 2FU and 4FU. Proceed with steps 5 through 17.

3. The -12V bus power output circuit cannot operate unless the +12V bus is functional. In order to check the -12V bus, leave 3FU and 4FU in place and remove 2FU. Proceed with steps 5 through 17. Make sure that the +12V bus always comes up to its nominal value every time the Control On pushbutton is depressed.

4. The Overvoltage Latch flip-flop sets every time the Control On pushbutton is depressed. It is reset by the following faults:

Bus overvoltage
Bus overcurrent
Bus output transformer primary current imbalance
Out-of-tolerance voltage on ±15VDC auxiliary buses

Test point 4PL-10 is connected to the set side of the Overvoltage Latch flip-flop.

5. Attach the oscilloscope probe to test point 4PL-10. Attach the digital voltmeter to the bus output.

6. Depress the Control On pushbutton and release it. If test point 4PL-10 indicates logic 1, go to step 13 below. If 4PL-10 indicates logic 0, proceed with step 7.

7. Read the voltmeter at the bus output while the Control On pushbutton is depressed. The indicated voltage should read close to the specified bus voltage. If it does, the bus is functional. If the indicated voltage does not read close to the specified bus voltage, proceed with step 8.

8. Attach the oscilloscope probe as follows:

TO CHECK:	PROBE LOCATION	OSCILLOSCOPE GROUND
+5V bus on PS105	22PL-1	PSG1
+12V bus on PS112	12PL-1	PSG2
-k2V bus on PS112	13PL-1	PSG3

9. Depress the Control On pushbutton. The observed wave form should be symmetrical and steady as shown in Figure 7C. If it is not, replace the power output board (PS105 or PS112) under test.

10. Attach the scope probe to the bus output terminal with the scope ground on the OV bus.

11. Depress the Control On pushbutton. The observed 20KHZ ripple wave form should be less than 100 millivolts peak-to-peak. If it is not, replace the power output board under test.

12. If the wave forms observed in 9 and 11 are acceptable but the bus voltage is less than the specified value, turn the potentiometer indicated in the outline below clockwise until the desired bus voltage is reached.

	POT DESIGNATION ON REG9 BOARD
For +5V	P1
For +12V	P4
For -12V	P5

13. If test point 4PL-10 reads logic 1 after depressing the Control On pushbutton, the bus under test may stay on for a short time only (25 milliseconds). Attach the brush recorder to the bus output terminals to observe this voltage.

14. Actuate the Control On pushbutton and record the bus voltage.

15. If the recorded wave form indicates that the bus exceeded the specified voltage, turn the Voltage Adjust potentiometer on the REG9 board (P1 for +5V, P4 for +12V, P5 for -12V) slowly counterclockwise until the desired value is reached.

16. If the bus fails to latch in after an attempt has been make to adjust its voltage, the fault may be in the unbalance in the power output transformer. For the +5V bus, replace the PS105 board. For the ±12V buses replace the PS112 board.

17. After checking the +5V bus go to step 2 above. After checking the +12V bus, go to step 3 above.

RENEWAL PARTS

Renewal parts for the 3N8100PS103A1 Switching Power Supply are given below:

Description of Part	Catalog Number	Quantity Used
REG9 to PS105 Cable	3N8100CA105A1	1
REG9 to PS112 +12V Cable	3N8100CA105B1	1
REG9 to PS112 -12V Cable	3N8100CA105C1	1
REG9 Power Cable	3N8100CA105D1	1
Printed Circuit Board (PS105)	44A399750-G01	1
Printed Circuit Board (PS112)	44A399751-G01	1
Printed Circuit Board (REG125)	44A399752-G01	1
Reactor (L1)	44B398034-001	1
Reactor (L2)	44B398023-001	1
Relay (IPOA)	44B218524-005	1
Capacitor - 4900 Mfd. 150 Volt (C1)	86F197L	1
Capacitor - 0.1 Mfd. 400 WVDC ± 20% (C2)	68A7052P1F20	1
Resistor - 220 Ohm. 10 Watt (R2/4)	K8622212E22	2
Resistor - 10 Ohm. 1 Watt (R3)	259A9011P100	1
Resistor - 2700 Ohm. 10 Watt	K8622212F27	1
Diode (D1)	44B232011-001	1
Diode Bridge (DB1)	259A9202P15280	1
Fuse - 6 Amp. 250 Volt (1FU)	K9774700P3	1
Fuse Block for above	44A399624-001	1
Fuse - 5 Amp. 250 Volt (2FU)	K9774740P10	1
Fuse - 3 Amp. 250 Volt (3FU)	K9774740P3	1
Fuse - 2 Amp. 250 Volt (4FU)	K9774740P5	1
Fuse Holder for above fuses	44A212119-001	3
Terminal Board (1TB)	44B211519-035	1

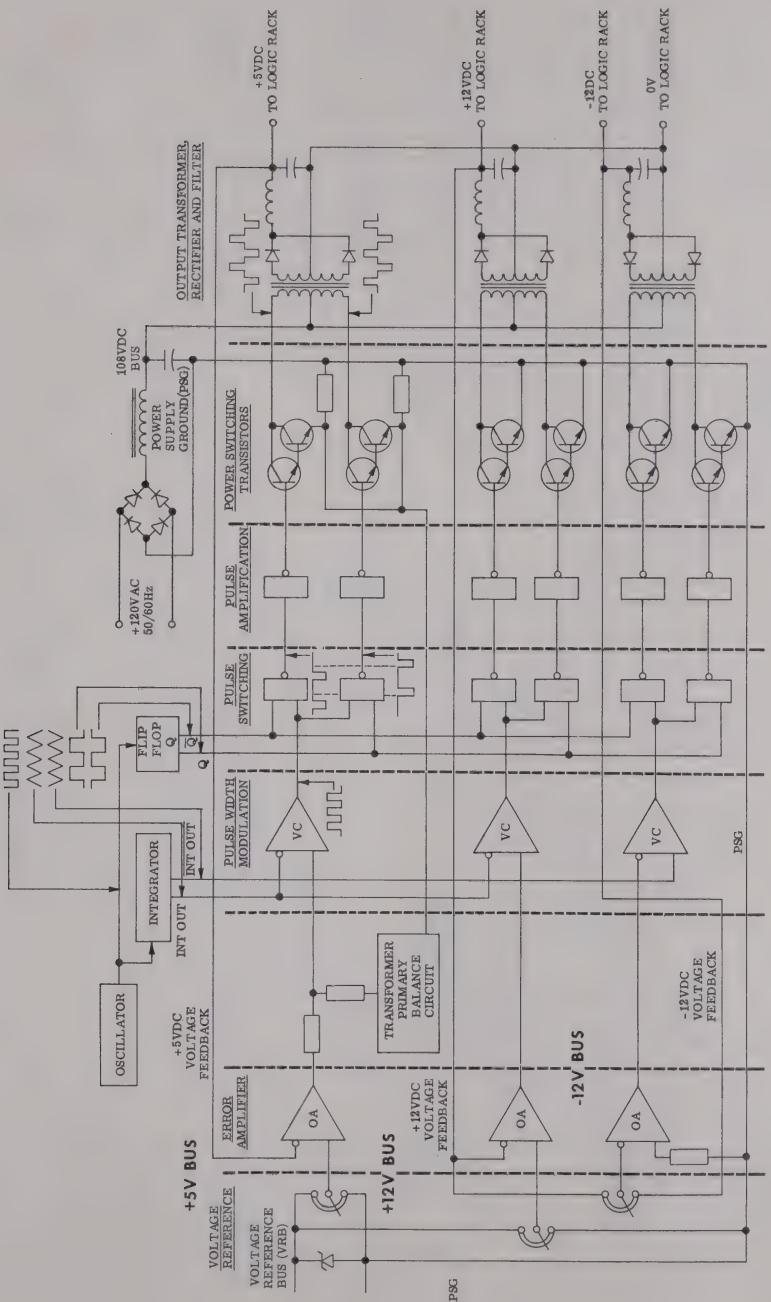


Figure 1.
FUNCTIONAL DIAGRAM OF POWER SUPPLY

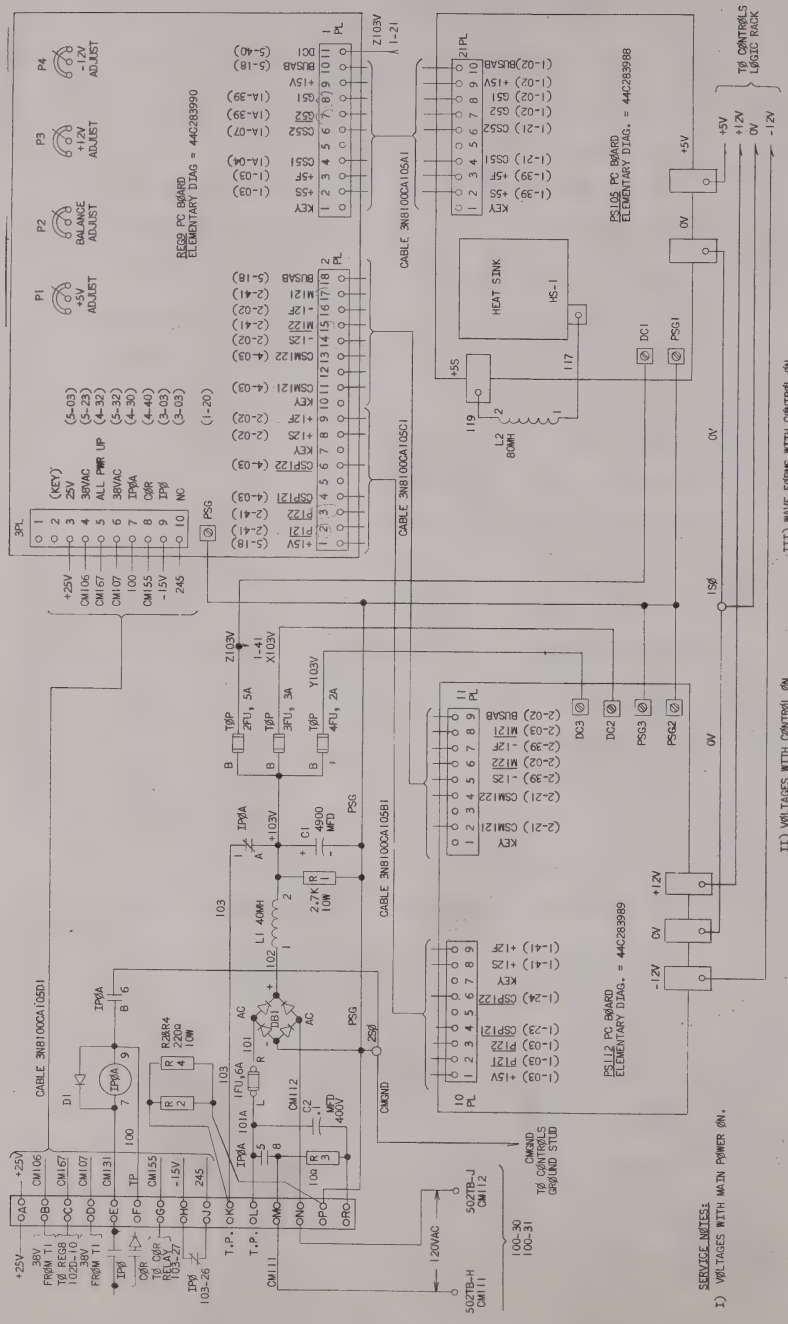


Figure 2.
ELEMENTARY DIAGRAM OF THE POWER SUPPLY

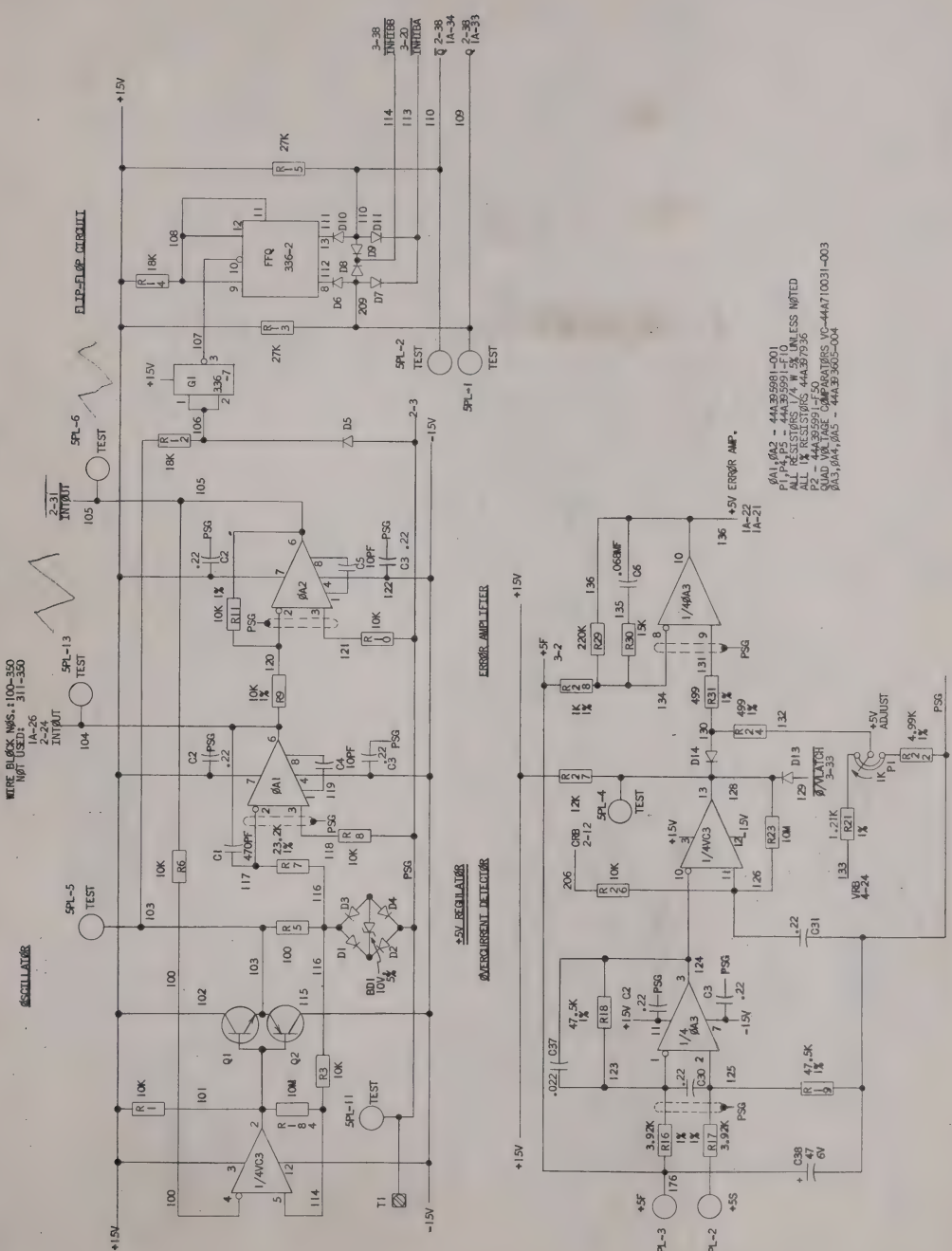


Figure 3A.
REGULATOR AND CONTROL BOARD-REG9
(Continued on page 14)

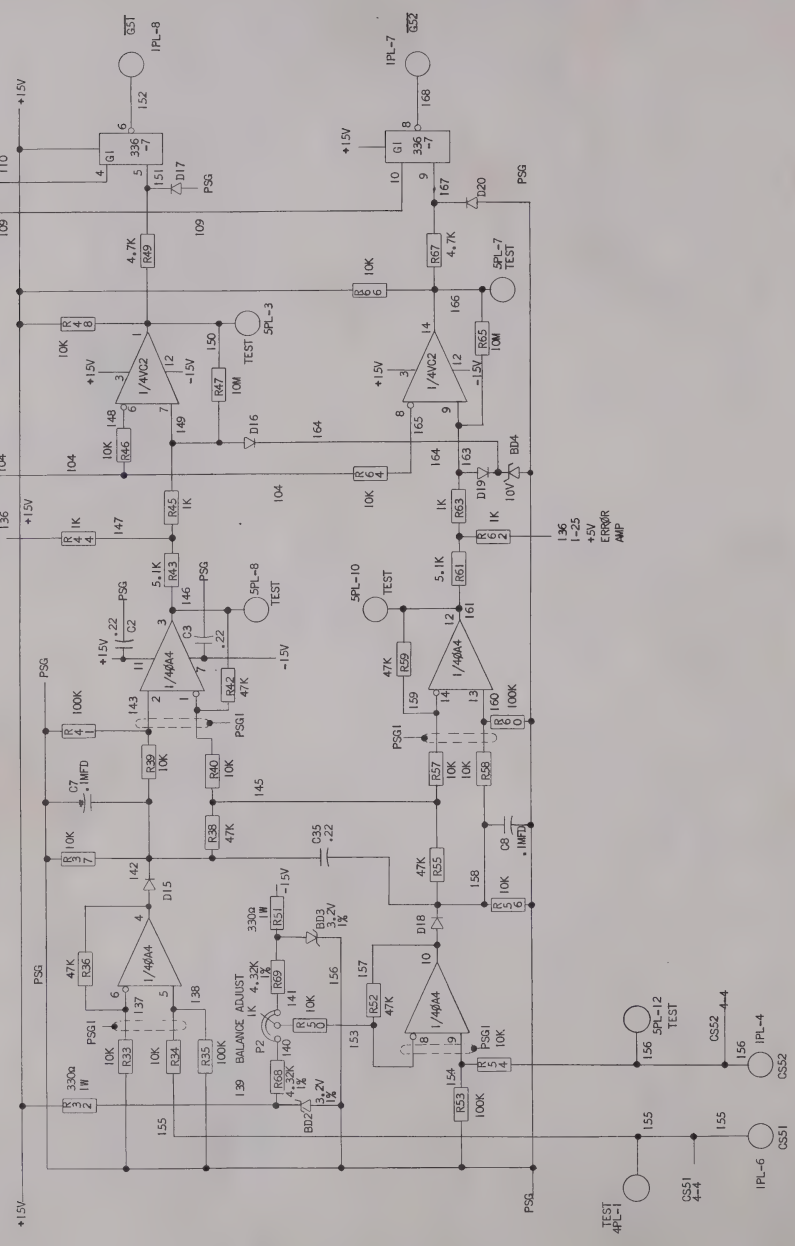


Figure 3B.
REGULATOR AND CONTROL BOARD-REG9
(Continued on page 15)

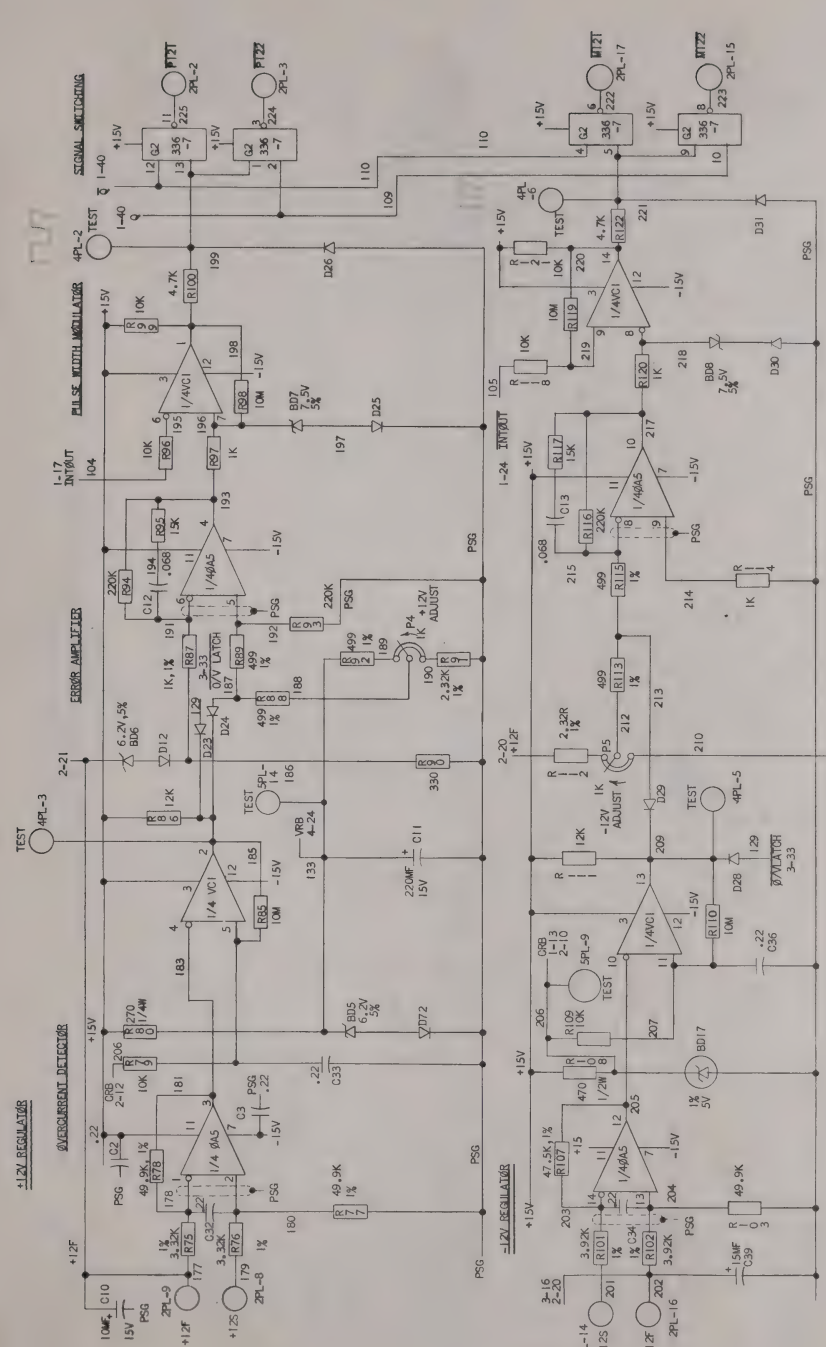


Figure 3C.
REGULATOR AND CONTROL BOARD-REG9
(Continued on page 16)

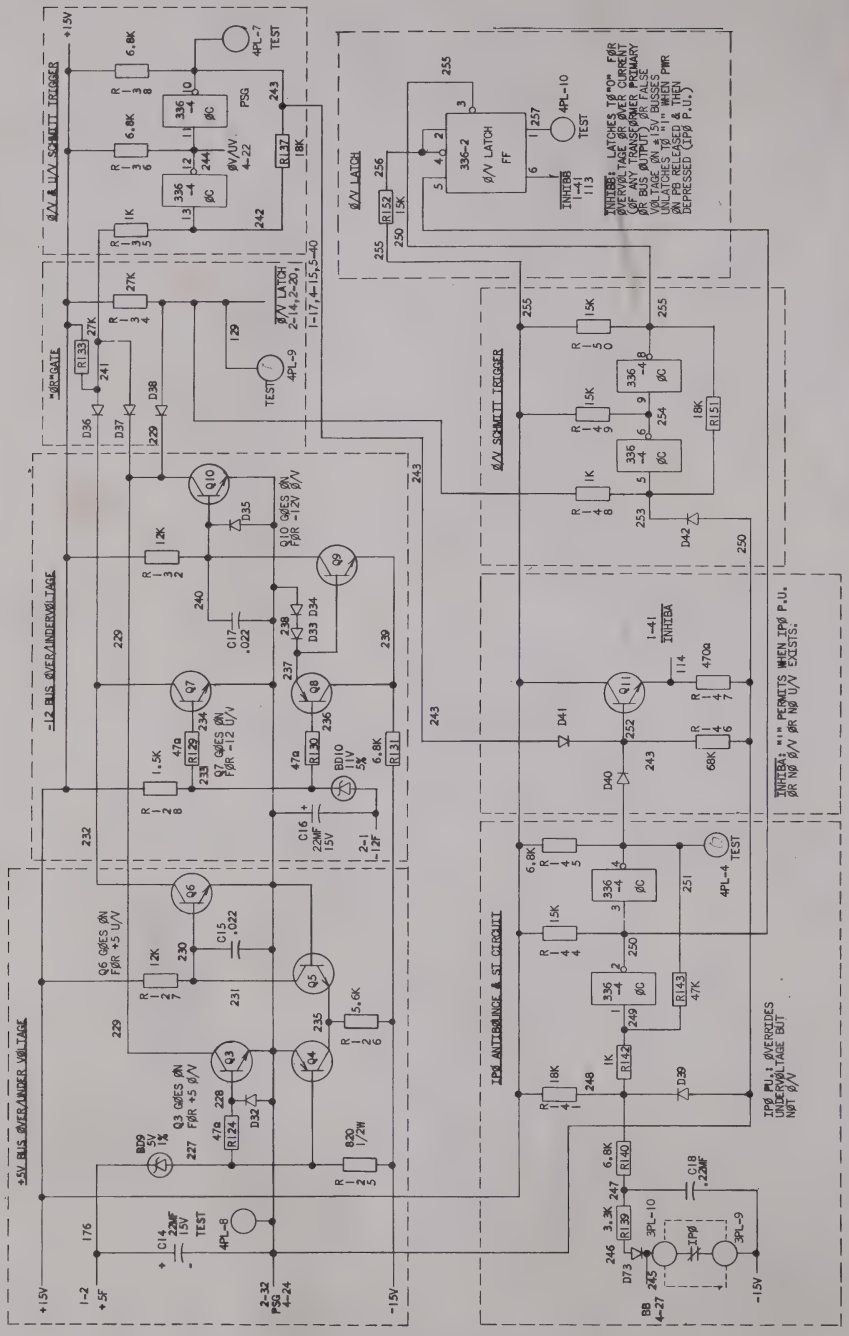


Figure 3D.
REGULATOR AND CONTROL BOARD-REG9
(Continued on page 17)

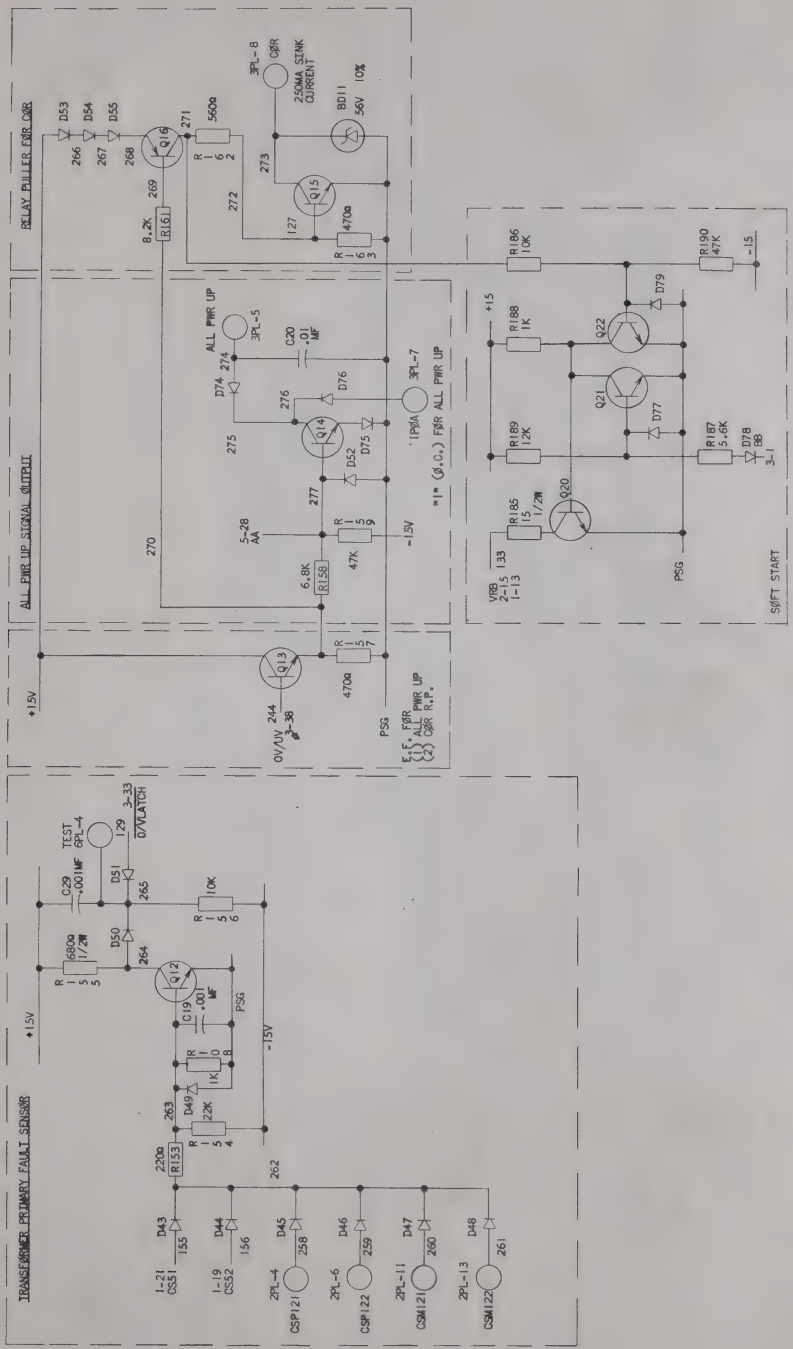


Figure 3E.
REGULATOR AND CONTROL BOARD-REG9
(Continued on page 18)

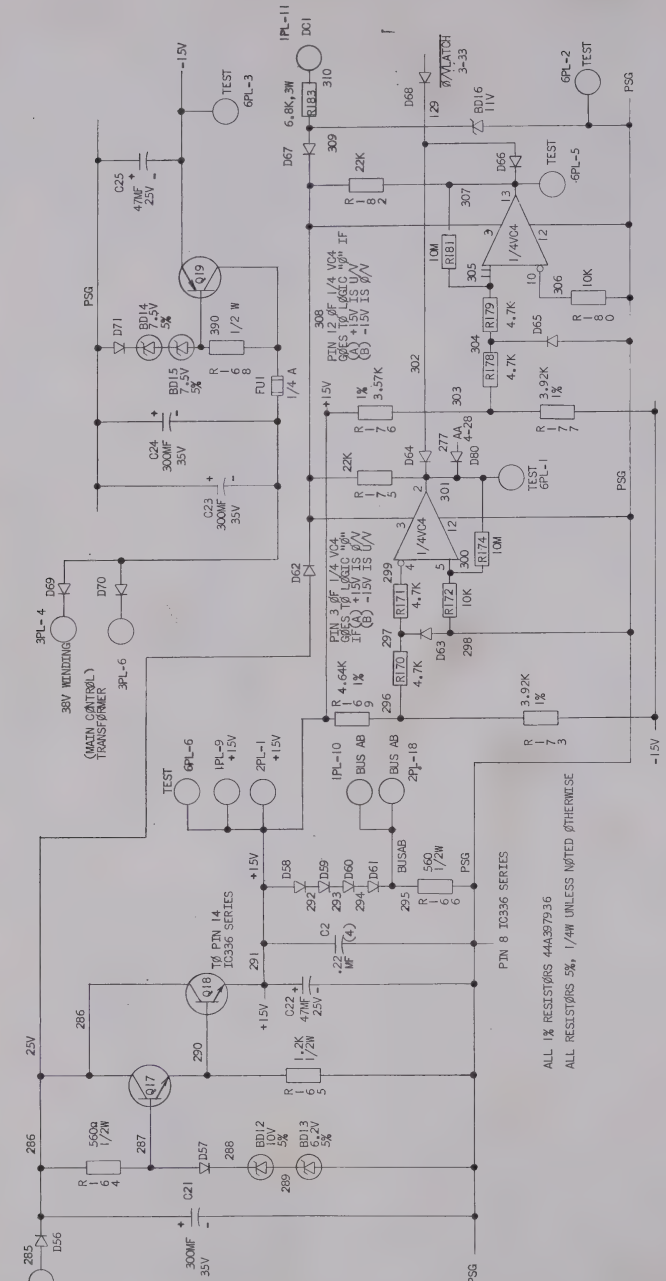


Figure 3F.
REGULATOR AND CONTROL BOARD-REG9
(Final)

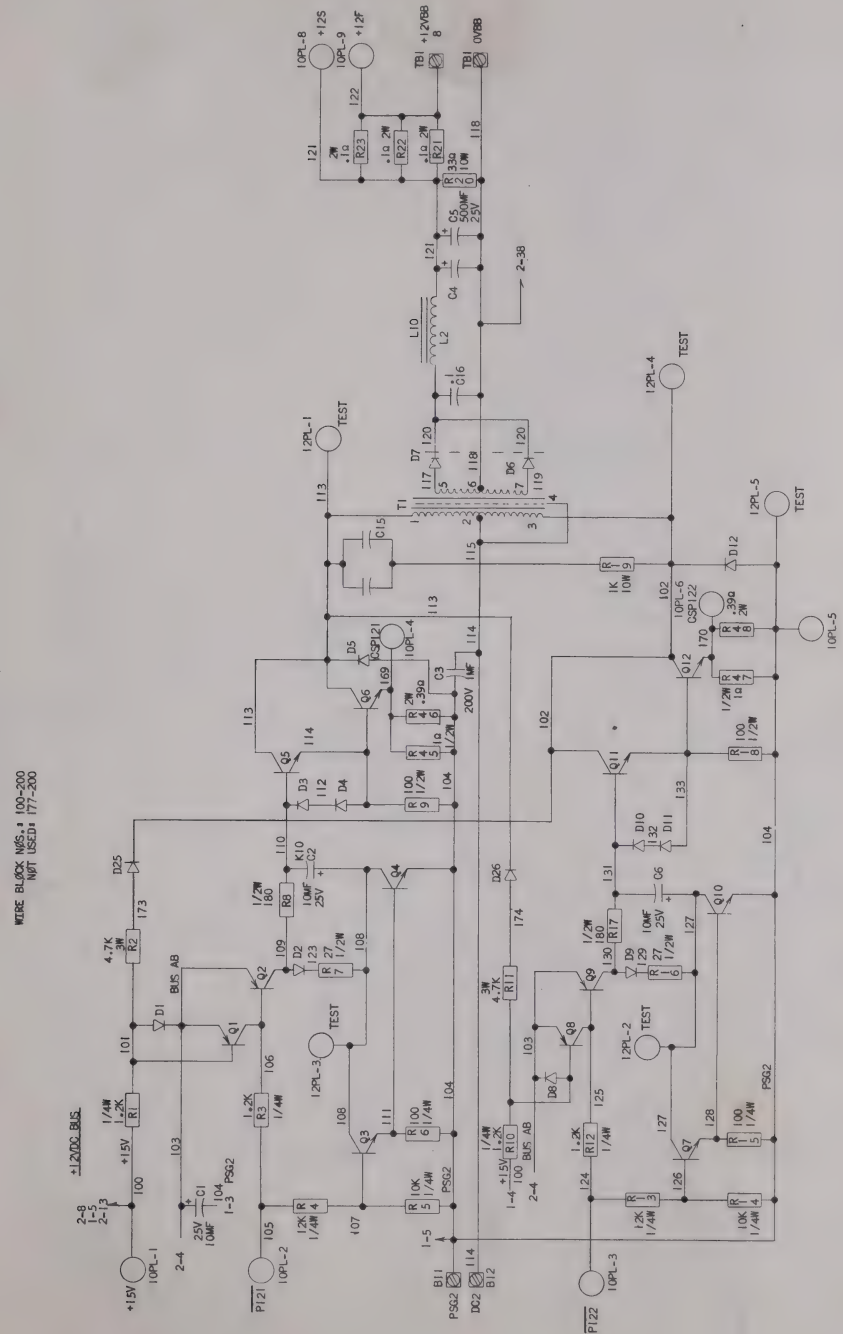


Figure 4A.
±12V POWER OUTPUT BOARD-PS112
(Continued on page 20)

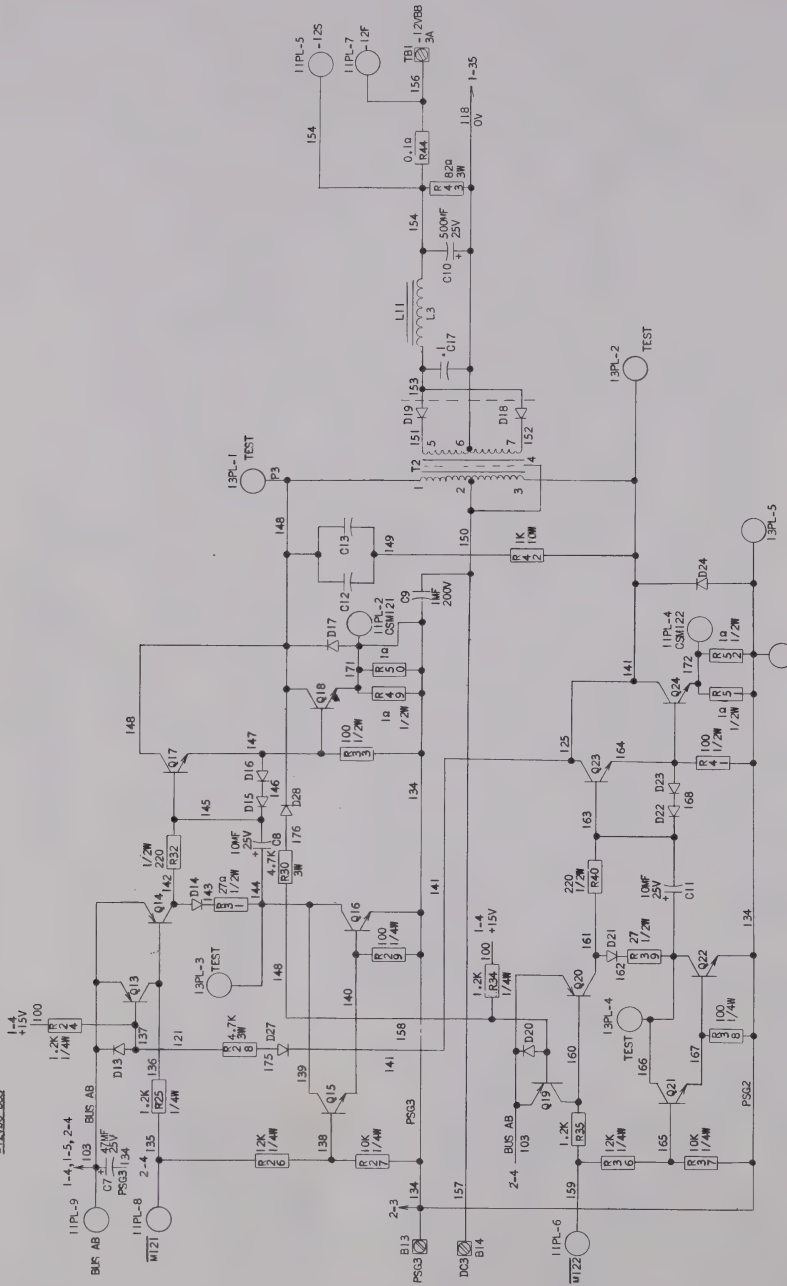


Figure 4B.
±12V POWER OUTPUT BOARD-PS112
(Final)

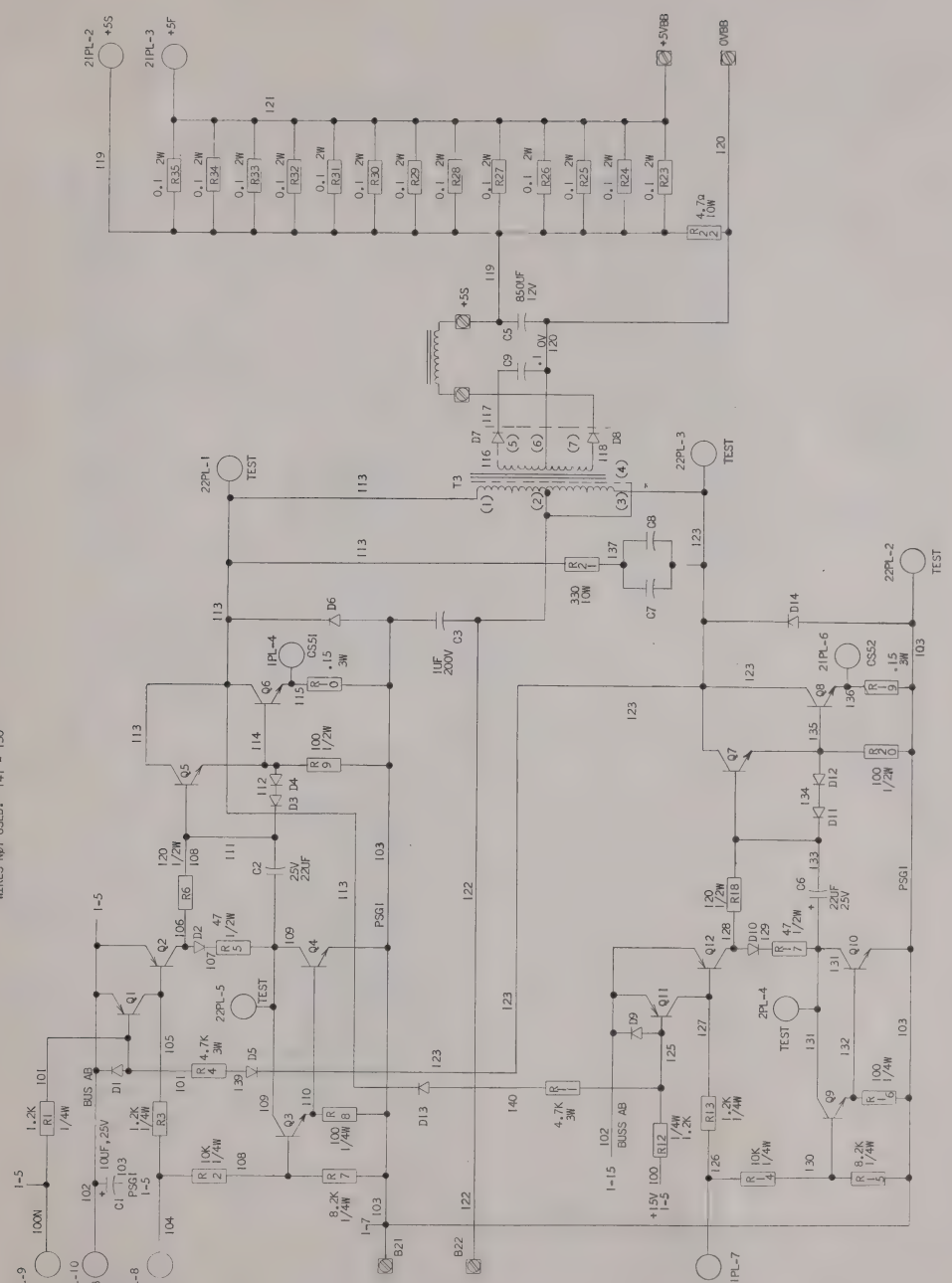
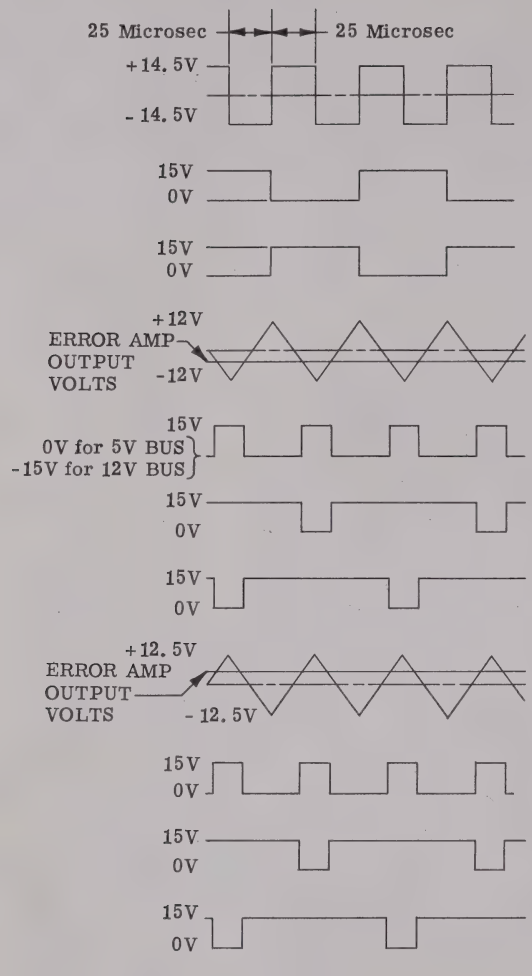


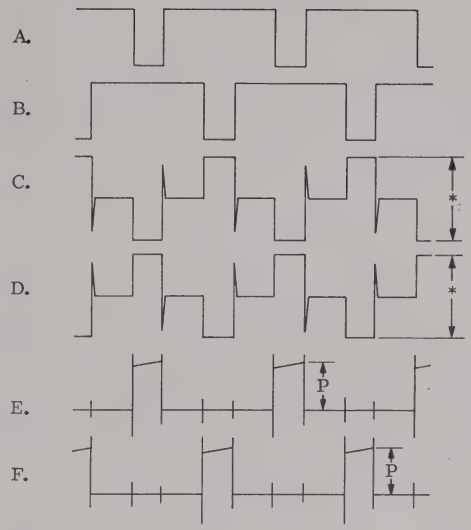
Figure 5.
POWER SUPPLY BOARD - PS105



			+5V BUS	+12V BUS	-12V BUS
A	OSCILLATOR OUTPUT	5PL-5			
B.	Q	5PL-1			
C.	$\overline{Q}$	5PL-2			
D.	INT OUT		5PL-13	5PL-13	
E.	VOLTAGE COMPARATOR OUTPUT FOR +5V, +12V		5PL-3 5PL-7	4PL-2	
F.	REG9 BOARD OUTPUT NO. 1 FOR +5V, +12V		1PL-8 ($\overline{G51}$)	2PL-2 ($\overline{P121}$)	
G.	REG9 BOARD OUTPUT NO. 2 FOR +5V, +12V		1PL-7 ($\overline{G52}$)	2PL-3 ($\overline{P122}$)	
H.	$\overline{\text{INT OUT}}$				5PL-6
I.	VOLT COMP. OUTPUT FOR -12V				4PL-6
K.	REG9 BOARD OUTPUT NO. 1 FOR -12V				2PL-17 ($\overline{M121}$)
L.	REG9 BOARD OUTPUT NO. 2 FOR -12V				2PL-15 ($\overline{M122}$)

NOTE: 1. All voltage values are approximate and are for reference only.
2. The waveforms are not to scale.

Figure 6.
PULSE WAVEFORMS FOR THE REG9 BOARD



	TEST POINTS ON PS112 +12VDC BUS	TEST POINTS ON PS112 -12VDC BUS	TEST POINTS ON PS105 (+5VDC BUS)
INPUT WAVE FORM TO POWER STAGE	10PL-2	11PL-8	21PL-8
	10PL-3	11PL-6	21PL-7
SWITCHING TRANSISTOR VOLTAGE	12PL-1	13PL-1	22PL-1
	12PL-4	13PL-2	22PL-3
TRANSFORMER PRIMARY CURRENT	10PL-4	11PL-2	21PL-4
	10PL-6	11PL-2	21PL-6

NOTE: 1. ALL VOLTAGE VALUES ARE APPROXIMATE AND ARE FOR REFERENCE ONLY.
2. THE WAVEFORMS ARE NOT TO SCALE.

* THE VOLTAGE THUSLY INDICATED IS APPROXIMATELY 2X OF THE VOLTAGE ACROSS CAPACITOR C_1.

Figure 7.
POWER SUPPLY OUTPUT SWITCHING WAVEFORMS

NOTES

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